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TABLE OF LEADING ARTICLES.

Illinois Geological Survey 169
Electrically Driven Pumps for Water-Works 169
Modern Bridge Erection 170
Bridges and Tunnels 171
The New York Port Problem 171
The Connecticut Ave. Bridge, Washington, D. C. (Illustrated) 172
Notes on Water Softening 173
Experience with Steel Sheet Piling in Hard Soils. (Illustrated) 175
Specific Gravity of Portland Cement 176
Building an Elevated Railroad Yard. (Illustrated) 177
Sinking and Lining a 6-ft. Well 178
Viaducts on the Guatemala Ry. at El Rodeo and Station 1132 179
The Jefferson St. Bridge, Newark. (Illustrated) 181
The Tehuantepec Ry. 183
Granite-Top Macadam in Oak Park 184
Improvements to the Water-Works System of Waupaca, Wis. (Illustrated) 184
Heating and Ventilating Plant of the United Engineering Building, New York. (Illustrated) 186
The Making, Indexing and Filing of Drawings. (Illustrated) 189
The Tankage Building for the Swift Fertilizer Works, Atlanta. (Illustrated) 191
T-Rails and Grooved Rails for Paved Streets 192
Book Notes 193
Transformation of Co-ordinates 194
The Ketterlinus Building 194
Steel Beams in Mill Construction 194

The Illinois Geological Survey.

The work done by the Illinois Geological Commission since its organization less than two years ago has been so important that the action of the Legislature in establishing the Commission is abundantly justified. The director, Dr. H. Foster Bain, did not assume the charge of the work until November, 1905, but since that time 2,492 square miles of territory have been mapped, important work has been done in the study of coal fields and the production and use of coal, a fine beginning has been made in the examination of the excellent clay beds of the State, the important oil and gas resources in the southern counties have been investigated, a large amount of miscellaneous work preparatory to the investigation of other resources of the State has been done, and a bureau has been established for answering questions concerning the mineral resources of the State. All this has been achieved with an appropriation of $50,000 for the two years' work; the results could not possibly have been accomplished for such a small sum were it not for the co-operation of other organizations and the existence of valuable surveys and collections of data forming a basis for much of the work. This journal is a firm believer in the importance to any State of geological work conducted along these lines, for it furnishes information of great value to those interested in the development of the natural wealth of the State and does much to attract capital.

The essential basis of any thorough geological work is a good topographic map, and, in order to secure this, the Illinois Commission has co-operated with the geographical branch of the United States Geological Survey, which has furnished the skilled topographers for the work. Fortunately the triangulation of the United States Lake Survey extends from the Wisconsin boundary to Crawford County, where it connects with the trans-continental triangulation of the United States Coast and Geodetic Survey; the Mississippi River Commission has triangulated the entire western boundary of the State, and surveys have been made very carefully under the direction of officers of the Corps of Engineers, U. S. A., from Alton along the Illinois River to Chicago. Precise levels have also been run by former commissions along parts of the State's boundary and across it, so that benches have been provided for extending the system of levels for topographic work, which has been conducted in the usual manner employed by the United States Geological Survey. The work done to date has cost but $16 per square mile. If it can be completed at this rate, and there seems to be no reason why it should be much exceeded, the results will prove the investment to be one of the best uses of State funds ever made, for good topographic maps are a great help in solving many other problems than those of a strictly geological character. In Illinois, for instance, land has been increasing in value at a very rapid rate, and its fertility has made the State one of the most important agricultural districts of the country. The proximity of this section to Chicago and St. Louis also affects the value of the land. The time is fast coming when the marshes and bottom lands must be drained and diked, and it is safe to say that the topographic maps now being prepared will be of great help in laying out this work on the most economical basis, particularly if the Commission receives funds for conducting stream measurements. The amount of property which will be reclaimed by drainage and thus be rendered highly productive will yield in additional taxes a sum sufficient in a comparatively few years to pay a considerable part of the expenses of the topographical survey.

The most important single mineral in the State is coal, and the manner in which the Commission has investigated the coal resources of Illinois may be stated as a demonstration of the value of the investigations. Necessarily a considerable part of the funds have been devoted to stratigraphic studies, since a thorough knowledge of the stratigraphy of the coal fields is necessary for determining the best methods of developing them. In the case of measures at Peoria, Springfield and elsewhere this is particularly desirable on account of puzzling faults and "horsebacks" that need investigation in order that a useless expenditure of money shall not occur. In part of this work the State has the informal assistance of the United States Geological Survey, thus lightening its expense to the State. The character of the coal is being determined in a manner which will be productive of highly valuable results to those who handle and use it. Samples are taken from clean faces in the mines and sent in airtight cans to the laboratory, so that the amount of natural moisture can be determined with reasonable accuracy. Attention is being paid to methods of mining, so that the present great waste may be curtailed. The effects of weathering and washing are being investigated, for it is highly desirable to have Illinois coal come on the market in such a state that the problem of smoke prevention shall be as free from needless complication as possible; it is already known that a great improvement can be made by paying more attention to this preparation of the fuel for use, but the business advantages of doing so are probably not recognized except by a few companies. Although proper treatment will greatly improve the Illinois coals, the market in the State has been occupied in a steadily increasing proportion by relatively smokeless Eastern coals, and the studies which the Commission is making to determine the best method of preparing and burning the native fuel are correspondingly important.

A good many other features of the work of the Commission might be cited in proof of the value of its work, but probably enough has been said to justify the opinion that the money spent for these purposes is an excellent investment. This journal is not favorably disposed to the expenditure of public funds for investigations that private individuals or companies can undertake. Doubtless there are various coal companies, brick companies and the like in Illinois which have ample resources for investigating the problems presented in their own restricted fields. These investigations do not attract outside capital to any extent, nor do they help to develop the mineral resources of the State as a whole, and up to the present time the only way to accomplish the latter desirable end is to organize and support by suitable appropriations just such work as the Illinois Geological Commission is now conducting.

Electrically Driven Pumps for Water-Works.

The steady growth in favor of electrically driven pumps for water-works purposes is a proof of certain advantages of such equipment which were first discussed in a general way at the 1895 convention of the American Water-Works Association. Prior to that time Prof. D. W. Mead had built a few stations with such pumps, there was one operated by a water company in Monroe, La., another by a water company at San Antonio, Tex., another at Canandaigua, N. Y., and perhaps a few others, certainly not more than a dozen all told. These were equipped with triplex pumps and direct-current motors, which were the best machines for the purpose at that time, although not to be compared for general usefulness with pumping units now in service. From this little beginning electrically driven plants have been slowly increasing in favor until it is now apparent that a few years will see an unusually large number of them installed. This will not affect appreciably the use of steam-actuated pumping engines, for it is difficult to imagine any electrical unit which can compete with a good steam pumping plant except when the current is furnished by a hydro-electric station under such favorable conditions that its cost to the pumping station is very low, as is the case at Lockport, N. Y., for which Mr. Charles A. Hague has designed an electrically driven station using power transmitted from Niagara Falls. The number of places where current can be obtained at such low rates is limited, and for this reason there seems to be little reason to expect to see the construction of many plants of that type.

In the case of small pumping stations, supplying water to communities having a population of but a few thousand people, the electrically operated unit possesses advantages only when the cost of getting fuel to the station is high, or when it is operated in connection with an electric lighting plant, so as to insure a fairly steady 24-hour load. If water must be pumped at a place remote from good roads or railways, it may prove economical to install a generating plant in some place favorable for a low boiler-room cost and transmit the power electrically, or it may be possible to develop a water power and transmit its energy electrically to the pumping station. The practicability of such a scheme has been affected materially of late by the improvements in centrifugal pumps. While the economical range of such equipment is limited, it is possible to employ them advantageously in stand-pipe or reservoir systems where they operate against a fairly steady head, and require to be speeded up only in case of fire. The most common case of small electrically driven pumping units occurs with deep-well pumps having a motor attached to the top of the vertical shaft rising from the pump runner or runners submerged in the well. Apparatus of this nature was developed a number of years ago for irrigation purposes in Southern California and has proved so successful and economical that it is gradually finding application in works for supplying water to cities and towns.

It is probable, however, that the most important early use of large-capacity electrical pumps will be in connection with existing water-works, either for high-service districts or for improving pressures in the outlying portions of distribution systems. In most large cities there are a few regions where the elevation of the houses and their increasing number eventually reduce the water pressure to an inconvenient amount. The quantity of water used daily is small and can be supplied from an elevated tank or reservoir filled once or twice daily. A steam pumping station for this purpose is expensive to operate, because fires must be kept up all the time although pumping is done but a few hours daily, thus producing the most undesirable condition for economical operation of steam plant. An electrically operated unit like that recently installed for high-service pumping at Montreal is particularly well adapted to improve this situation. There is no charge for current except when it is used, and it is only necessary to throw a switch in order to put the machinery into service. There is no boiler plant to disfigure the vicinity with its ugly chimney and smoke, and the apparatus can be started up without any delay in raising steam in case of any emergency. If the amount of water required for the high-service district is small, a small equipment can be installed without any marked drop in the efficiency of operation, for it will be about the same as with a large plant, and the equipment can be duplicated without any great trouble, since there is no bulky boiler plant to be housed.

The second class of service for which such units seem particularly adapted in relieving the special needs of growing cities is equivalent to that of the booster sets employed in electrical distribution systems. As a city develops and its mains are extended into the outlying districts the six and eight-inch pipes used to furnish water to people living on what was formerly the fringe of the place become inadequate to supply the amount of water demanded. The friction losses in the pipes are so great, owing to the roughening of their interior surfaces and the greater drafts of water, that the pressure on the mains at the pumping stations is not enough to supply the demands in the outskirts of the city. It is then necessary to lay larger mains, a work which is very expensive, as a substitute for those in service, although the latter may be in good condition. It may happen in some cities that there is a considerable portion of suburban territory that can be supplied through one or two trunk mains and in such a case the electrically operated pumping plant affords a solution of the problem. These mains can be connected and a pumping plant installed at their junction, or a smaller plant can be installed in each of them. These units will draw water from the mains and deliver it under any desired increase of pressure back into the pipes running to the suburban territory, thus increasing the head there and doing for a small cost what larger mains would have to be employed otherwise to accomplish. This is a temporary expedient, not to be compared for a moment with the service to be rendered by large supply mains, but it affords a relief that might properly be employed during the term of years when the original system of mains is somewhat too small for the increased demands upon it, but is not so small that the daily supply is seriously affected. In its essential principle this case of service does not differ from high-service pumping, and while it has very rarely been employed there is no reason why it should not afford a remedy for the conditions that often arise in the management of water-works systems.

Modern Bridge Erection.

The assembling and putting in place of the manufactured members of a steel bridge superstructure, like all parts of early bridge building, was at first comparatively simple after the staging was set up. It involved little else than coupling the members together in the case of pin-connected bridges and the simplest class of hand-riveting, subject to no drastic inspection and frequently with results which would now be considered decidedly indifferent in case of riveted bridges. The old pin-connected truss with abutting joints in compression members was erected with the simplest and crudest contrivances involving little really skilled labor, and with corresponding speed under all ordinary circumstances. While the process of erection of the early riveted bridges was certainly more involved and required a higher grade of skilled labor as well as a greater force, the whole procedure was comparatively simple, especially in view of the fact that a quality of riveted work was then readily accepted which would not now be tolerated under any circumstances when field riveting is subject to requirements little if any less exacting than those demanded in the shop.

With the short spans of early bridge construction, the placing and fit of members on the falsework staging involved no special degree of accuracy compared with that which is demanded in the modern long-span bridge erection. Although negligence was no more tolerated in this class of work in the early years of iron and steel bridge construction, probably, than at present, the need of refined accuracy did not exist. It was not only impossible to reach the degree of perfection now attained in shop work, thus requiring less accurate treatment in the field, but the demands of the modern heavy and rapidly moving railway loads had not then arisen. The excellence of field work in modern bridge erection is like all other advances in engineering work, a complex result; it has been reached by a kind of mutual interaction of the increasing demands of transportation and a concurrent development of capacity of the shop to produce greater and better bridge members. There has been such a marked advancement in bridge erection as to result practically in the extension of shop procedures into field work. It goes without saying that this does not hold true of all the bridge work now executed, but the observation is markedly applicable to all the larger work turned out by the best bridge shops of the country.

These statements are probably as fully justified by the field work in the erection of the cantilever structure being built across the St. Lawrence River near Quebec, as by any iron or steel bridge construction yet completed. The erection of the main posts of this bridge was fully described in The Engineering Record of Jan. 26. The procedures involved in that work show what elaborately accurate operations are required for the mere placing in position of the manufactured members, to say nothing of the nicety of fitting of the members themselves assembled for the first time on the falsework.

This has all been made possible by advances in both design and shop work. However carefully the members of a structure may be put in place in the field the erection of the structure would be impracticable if not impossible unless the design were carefully considered and the shop work accurately executed. Especially is this true of a great structure like the Quebec cantilever or the long span suspension bridges across the East River in New York, in which certain conditions of initial stress or of dimensions depending upon temperature must be scrupulously respected. If the manufactured parts of the structure were not properly disposed on the falsework staging, or if the fitting of those parts were so indifferent as to require the application of much force to bring them together with joints either crudely formed or with such violence as to produce permanent distortion of the metal, the results of the field work might be of a dangerous character and in many cases the stress computations would be seriously demoralized. There is less danger to be apprehended from these bad erection conditions in the cantilever bridge than in the stiffening trusses of long suspension spans or in long steel arched ribs, but it is one of the greatest responsibilities of modern erection work to avoid them. The resulting prejudicial stresses may be of high intensity and they are just as likely to concur with the legitimate stresses in the various members of the structure, and thus produce serious overstressing as to neutralize them either partially or wholly.

These considerations demonstrate the imperative necessity of advancing the excellence of shop work in any practicable way. In fact the best possible shop operations based upon an equally excellent quality of design are the very foundation of the best modern field work. This is a sufficient justification for every advance in modern shop administration aside from the fundamental necessity for improving the quality of work for its own sake.

The successful putting in place on a masonry pier at Quebec of a built steel tower over four hundred feet high in addition to the adjacent anchor and cantilever trusses is a remarkable achievement, although operations of less magnitude have become so commonplace that they occasion little or no remark. When the shop of Sir William Arrol literally had to be taken to the site of the Forth cantilever it was said frequently that the work had been made the most difficult possible for the contractor, but generally speaking that is essentially required in the erection of every great bridge span at the present time. The development of special field tools, such as those of the pneumatic and electric classes, make this transference of the shop to the field comparatively simple, although in fact the employment of power appliances in bridge erection is actually extending shop operations to the bridge site. Rivet driving, reaming and other similar operations by hand are already antiquated and seldom acceptable. It is no longer possible to attain by the older handwork either the excellence, the speed or the economy now universally demanded in this part of bridge construction.

Bridges and Tunnels.

Possibly a good many people wonder what is the use of talking about a bridge across the Hudson River between New Jersey and Manhattan, now that so many tunnels are being driven under that stream. Ten years hence, after they have become accustomed to tunnel transportation, it is probable that the desirability of such a bridge will be fully understood. Tunnel transportation at its best is extremely disagreeable, and at its worst it is almost unbearable, and if anybody can spare the time to take an overhead rather than an underground trip he will generally do so when he has a choice of routes. Beyond any question, the development of tunneling through soft material has become a very important and useful factor in the development of New York, for the opening of tunnel traffic with New Jersey will make a material change in the tendency of people doing business in New York to live in New Jersey. The relatively low cost with which a pair of tunnels can be driven from shore to shore as compared with the first cost of a bridge across the river makes tunneling the logical solution of pressing transportation needs, and it has naturally been carried into effect first. It is by no means a complete solution, however.

The population on each side of the river is sufficiently great and crosses the river in sufficient numbers to make the construction of a bridge a justifiable measure provided access to its terminals can be afforded by such routes that a large number of people will find the structure useful. In the course of the various investigations made by private companies interested in bridge projects for spanning the Hudson River, it was pretty clearly shown that such a structure would be a good business investment provided an elevated track along the New York water front were permitted. This elevated railway scheme was vetoed by the governor of the State, and accordingly the project was allowed to lapse into obscurity, deepened by the determination of the Pennsylvania R. R. Co. to abandon any idea of entering Manhattan by a bridge and instead to construct the great tunnels which are now being finished. This decision by the company, which was originally the leading supporter of one of the bridge projects practically stopped all consideration of a Hudson River bridge until an interstate commission, representing both New York and New Jersey, was appointed about a year ago to investigate the subject. There has been a strong feeling that the interests of the people living in the adjacent parts of the two States demanded at least one avenue of communication not controlled by private transportation companies, and that it was only right that this should be a bridge were it practicable to construct one. Tunneling under favorable conditions is so much cheaper than bridging great rivers that private companies will plainly adopt the former, but the desirability of a bridge allowing vehicles and pedestrians to cross the river and enabling electric cars to go from shore to shore without a trip underground, which is very objectionable to many people, naturally points to such a structure as peculiarly appropriate for the two States to undertake.

The project as outlined by the New York members of the Commission calls for a bridge between New Jersey and some point in Manhattan between 14th and 72nd Sts. This is estimated to cost somewhere between $25,000,000 and $35,000,000, exclusive of perhaps twice that sum for land for approaches which is not mentioned in the report. The structure is suggested as primarily one for vehicles, pedestrians and electric cars, including a high-speed line connecting with all the railway terminals on the New Jersey shore and carrying baggage as well as passengers from a Union station in Manhattan. The commission's New York members also report in favor of two bridges connecting Staten Island with the mainland and thus giving that part of the city transportation facilities which it much needs if it is to develop as rapidly as its position warrants. At the time of writing the New Jersey members of the commission had not made public their views, probably because it has been the policy of the present administration of that State to avoid approval of any measures which relate to intercourse with other States until their effect on the people of New Jersey can be carefully considered. As a matter of fact, it may be doubted whether the project will be carried very far during the next few years. The communities on both sides of the river need all the money they can raise for more pressing wants, particularly in view of the early completion of a number of tunnels furnishing a relief to the slow ferry service. On the other hand, the discomforts of this tunnel service will probably be such that not many years will pass after it has been thoroughly tried before the great bridge across the river will be undertaken.

The New York Port Problem.

Not long ago it was announced in the daily papers that unless one of the great transatlantic steamship companies could obtain less expensive dock facilities it would be compelled to curtail its service to the port of New York, and there were a number of editorials on the grave commercial danger of such a proceeding. This threat is complete nonsense, for the importance of the port is so great that there is no likelihood of any decrease in the passenger service to it; the ricidulous character of the assertion is immediately apparent when the attractiveness of a fast passenger service from Baltimore or Newport News to European ports is considered. The statements are on a par with those which often appear concerning the methods of handling passenger and freight traffic at the port, for probably no harbor on our coasts is so frequently the subject of unwarranted accusations as that of New York. While it is by no means perfect in many respects, it is conducting an enormous business with reasonable dispatch and without excessive cost, all criticisms to the contrary notwithstanding.

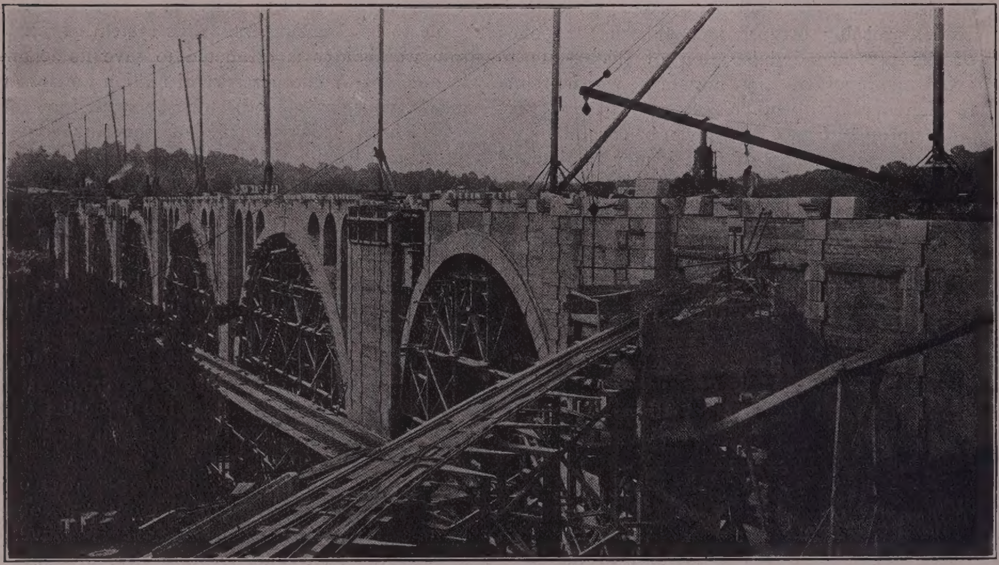
One of the most common charges against the port is that the system of handling freight cars between railroad terminals by floats is enormously expensive. This is not true, as a little reflection will show. At large cities where terminal railways are employed to deliver cars from one road to another, the land occupied by the tracks costs a great deal, the expense of keeping men at street crossings and switches is heavy, and the maintenance charges for keeping the railway in operating condition are large. In New York, all of these expenses are avoided. The car floats and docks are not costly as compared with miles of railway, while the tugs and crews are not expensive. The floats are towed about the harbor as quickly as cars are moved on a busy connecting railway, as is proved by the fact that the great freight steamships running regularly to the port are able to handle a greater amount of cargo in a given time in New York than in European ports. The cost is higher, but the explanation of it is that wages are much higher here than there, and a large part of the expense of handling freight in the harbor as in any other terminals, inland or on the sea coast, is for labor.

A number of years ago transportation circles were greatly interested in the warehouses in St. Louis built by the Samuel Cupples Real Estate Co. The first of these was described in this journal on Oct. 20, 1894, and from this small beginning a group of warehouses covering thirty acres have been built. Tracks extend into each of them from the terminal railway, and all handling of the freight, including the preparation of bills of lading, between the cars and the premises occupied by the tenants is done by employes of the company. The only handling of freight by employes of the tenants is for the delivery trade to local customers. This system of wholesale warehouses is estimated to save its tenants in one way or another several million dollars annually, which would otherwise be spent for needless labor. This example of concentration of effort and elimination of labor is probably the direction in which the wholesale handling of merchandise will be brought to a minimum basis of expense in the port of New York. The facilities for handling grain at some of the modern elevators in the harbor are equal to those anywhere, and the same thing is true of other bulk freight. The situation for wholesale merchandise houses has been different, however, and at the present time there is but one example at the port of the same system that has made the Cupples Station such a success. This is the Bush terminal in South Brooklyn. Here there are a series of wharves, each 150 ft. wide and a quarter of a mile long, with a system of fireproof warehouses behind them. The export freight is delivered directly to the steamship from cars brought to the terminal on lighters, and the import freight is loaded directly into the cars which are to take it to its point of destination. The goods are never carted about, except for local trade, for if it is necessary to store them they are taken directly into the warehouses at the terminal. The system eliminates the enormous disadvantages of warehouses in the crowded districts of the city, where goods must be handled and carted at great expense before they are housed and then be subjected to the same heavy charges when they are delivered. The plan is proving very successful in New York, as it is in St. Louis, and it will be strange if the great expense of land and labor in New York does not eventually lead to its extensive adoption for a considerable part of the wholesale warehouse business of the port.

The Cost of Filtering Water with slow sand as compared with mechanical filters in the Borough of Brooklyn, New York City, seems to indicate that the slow sand plants have the advantage in economy of operation. According to the recent report of Mr. I. M. De Varona, chief engineer of the Department of Water Supply, Gas and Electricity of New York, the two slow sand plants of the Brooklyn works filtered during 1905, 416,783,400 and 1,075,331,440 gal. of water at a cost of $2.89 and $2.28 per million gallons, respectively, while the two mechanical filters during the same period delivered 1,435,509,460 and 694,611,415 gal., at costs of $6.53 and $9.58 per million gallons. In the case of each of the mechanical filters the cost of operation represents about half the total cost and the interest and sinking fund about one-third, the remainder of the cost being charged to inspection, laboratory and repairs. The cost of labor and materials on the slow sand plant which was operated for $2.89 per million gallons was about 20 per cent. of the whole, the interest was a little over 27 per cent., and inspection and laboratory made up the remainder of the cost. On the other slow sand plant labor and materials cost about 29 per cent., interest about 43 per cent., and the remainder was charged to inspection and laboratory.

THE CONNECTICUT AVENUE BRIDGE, WASHINGTON, D. C.

The $800,000 highway bridge carrying Connecticut Ave. across Rock Creek at Washington, at a height of about 120 ft. above the water, is a handsome massive structure somewhat modified from the first prize design of the 1897 competition. Construction was commenced in 1898 and has since been carried forward under several contracts awarded to conform to the successive congressional appropriations and is now substantially completed. The design and details of the arch centers were illustrated in The Engineering Record of July 5, 1905, and June 2, 1906.



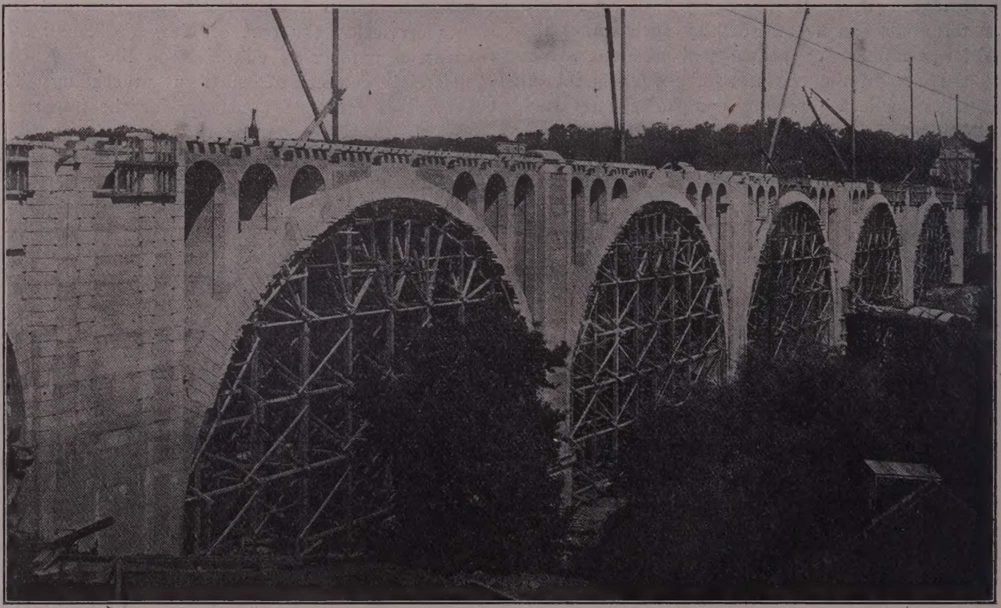
View Showing Double Track Service Platform and Tracks Delivering to Concrete Mixer.

The bridge, 52 ft. wide over all, has a 35-ft. roadway and two 8-ft. sidewalks, and comprises two approaches made with solid fills between longitudinal side walls, two 82-ft. and seven 150-ft. full-centered arches with two abutments and nine intermediate piers, the foundations all being carried down in open cofferdams to solid rock at a maximum depth of 40 ft. below the surface.

The entire structure is made of Portland cement concrete which is proportioned for the calculated stresses without reinforcement, except a few small steel bars used in the thin walls to prevent possible expansion cracks, pairs of 4x1-in. horizontal bars in the tops of the spandrel face walls, and reinforcement in the roadway arches proportioned to provide tensile strength for the semi-spans to act as cantilevers if the temperature movements should open the crown joints and destroy the arch action there. An important feature of the design is the use of large molded concrete blocks for the face rings of the arches, the corners of the piers, the molded courses and in general for all quoins and trimmings below the granite coping.

The ends of the arches are made integral with the massive rectangular piers up to a point about 30 deg. above the springing line, where the pier masonry and the arch masonry join in a plane normal to the intrados which virtually constitutes a skewback joint. Between the skewbacks, the main arches are each made in fifteen transverse sections separated by radial planes or construction joints. The massive rectangular piers and abutments are solid up to the skewbacks and above them have comparatively thin exterior walls braced by longitudinal cross walls and enclosing large hollow spaces. The floor platform is carried by 14-ft. transverse arches supported from the main arches, piers, and abutments by transverse walls, pierced in the lower part by arched openings. The tops of the arches are waterproofed and covered with concrete, above which is the earth fill and asphalt pavement.

The longitudinal face walls are battered inside to a maximum thickness of from 3 ft. over the crown of the main arches where they are 7 ft. high, to 20 ft. in the abutments where they are 50 ft. high. They are provided in the abutments with tongue and groove vertical expansion joints containing 8x8-in. wells filled with puddled clay.



View of Nearly Completed Bridge.

Vertical transverse expansion joints ½ in. wide are also provided in the concrete filling and in the spandrel walls at the center of each main arch and of each spandrel arch and are filled with lime mortar. The arch concrete is made 4.5:9:20.25. The footings are made 4.5:13.5:45, all with Vulcanite Portland cement. The molded blocks, however, are made 1:2½:6 with Dragon Portland cement.

A working platform about 20 ft. wide and 70 ft. high was built on falsework alongside the bridge from abutment to abutment and together with the arch centering cost about $50,000. The arch centers were composed of transverse vertical bents of square timbers seated on transverse rows of piles and thoroughly braced longitudinally and transversely.

The piles were proportioned for maximum loads of 25 tons each, and were tested with 38-ton trial loads which produced a permanent settlement of only 1/16 in. in 24 hours. Some of them penetrated 10 ft. into the rotten rock. In the river bed and under an intersecting bridge where it was impossible to drive piles, the trestle bents were seated on concrete piers carried down an average of 12 ft. to solid rock. A water main, under heavy pressure, was carried the full length of the bridge and the falsework was kept wet to avoid danger of fire and to keep the joints swelled during construction so that afterwards it could be allowed to dry and by its shrinkage swing the spans independently of the wedges.

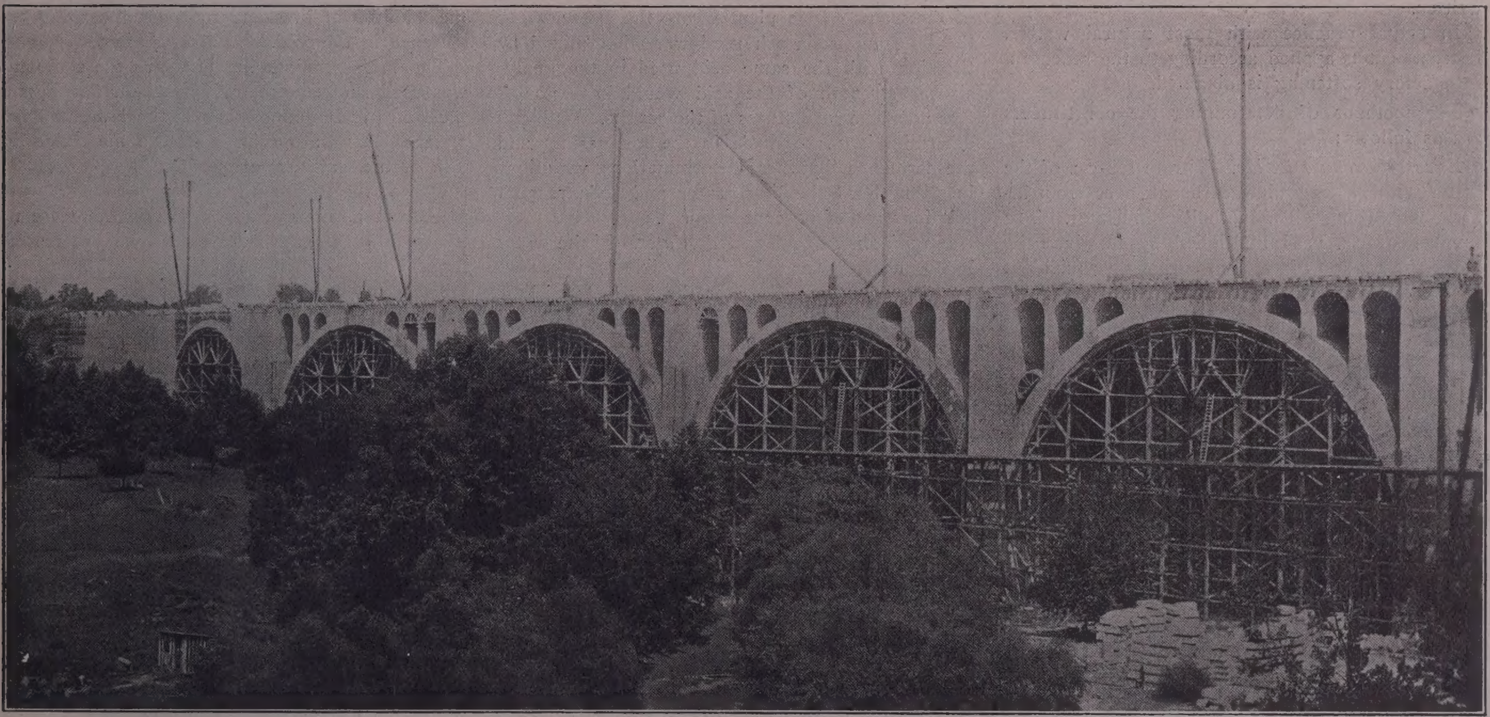
A little above the skewback joints a series of intermediate braces were introduced between the main bents to carry inclined struts supporting intermediate transverse beams, which together with the transverse beams in the planes of the bents were supported between vertical posts by inclined braces. All of these supports are adjustable with pairs of wedges and carried 3x12-in. inclined longitudinal joists 16 in. apart on centers to receive the lagging.

Concrete stone, quarried near the bridge site, was crushed at the rate of 350 cu. yd. daily and delivered to a storage pile provided with a tunnel for 3-yd. dump cars filled through gates in the tunnel roof and hauled by cable to the top of an incline where they discharged to an elevated storage bin. Sand delivered in the same manner, and cement chuted from the top of the bank, were stored in adjacent bins and charged by gravity to the concrete mixer which delivered to buckets transported by gravity cars to the service track and handled by a series of large mast and boom derricks seated on the bridge.

The molded quoin blocks were laid up in mortar to form the corners of piers, and to them horizontal tongue-and-groove boards, planed and oiled, were secured for the walls of the concrete forms. The boards were stiffened with vertical studs and horizontal wales, tied together through the pier by permanent ¾-in. horizontal rods with end sleeve nut connections removed when the forms were taken down. The pier forms were built up about 30 ft. above the springing lines with divergent transverse faces overhanging the lower part to form the "umbella tops" of the piers integral with the lower ends of the arches. The concrete was mixed very wet and laid in courses not more than 5 ft. thick.

After the molded voussoirs in the face rings were set between the skewbacks, the monolithic arch between them was built, as before stated, in transverse sections with widths of about 10 ft. measured parallel to the bridge axis, corresponding to five voussoirs each. They were built in alternate sections beginning at the skewbacks on both sides of the center. Next, the second and then the fourth sections, both of them at about the haunches, were built, then the crown section and afterwards the open spaces between the other sections were successively filled in until the arch was finished, care being taken to work both sides of the center at once and to build all of the arches simultaneously, thus insuring balanced thrusts at the piers and symmetrical loads on the falsework.

The sixth and seventh sections, on the most steeply inclined part of the arch, were each built in five portions separated by longitudinal bulkheads. The second and fourth portions, counting from either face of the arch, were first built, forming struts to hold the adjacent previously completed upper section from slipping downwards. Afterwards the partitions and intermediate braces were removed and the spaces left between the first voussoirs were filled, completing that portion of the ring. All of the other sections were cast full width in single operations without the intermediate longitudinal partitions.



General View of Falsework, Centering and Derricks.

The upper part of the arch concrete was enclosed by form boards for the first four sections beyond each skewback. Above the fourth section, the slope was so small that the upper surface of the concrete was finished with a trowel. While the first sections at the haunches were being cast, the falsework was temporarily loaded to secure weight equivalent to that of the finished structure and the arch was keyed by the simultaneous construction of the two last sections, each about 15 ft. from the center line and separated from each other by three courses that had been made third and fifth in the above described sequence of operations. These precautions had very satisfactory results, the average settlement being only 2½ in. A small amount of arch concreting was done in August, 1906, but it was not considered as effectively commenced until September 13 and was finished November 6, thus completing in 48 days, 8,884 cu. yd. of concreting. In order to avoid danger of cracking, lead joints were made between ring voussoirs and at every joint between them and the adjacent concrete sections.

The molded blocks were made 4.5:9:20.25, faced on the exposed sides with 1 in. of 1:3 screened crushed granite mortar. They were cast in wooden molds with collapsible sides, each of which was provided with six bottoms so that they could be stripped when 24 hours old. All of the blocks were dated and none of them were allowed to be placed in the structure until they were at least 60 days old. The new blocks were covered with canvas and thoroughly wet twice a day for two weeks. After they were 40 days old lewis bolt holes were made in them with pneumatic hammers and the exposed faces were dressed with four cut pneumatic bush hammers. Holes were also cored where necessary in the faces of the blocks to provide bond with the monolithic concrete backing.

Mr. Edward P. Casey was the consulting architect and the bridge was constructed under the direction of Col. John Biddle, U. S. A., Engineer Commissioner of the District of Columbia, and Capt. J. J. Morrow, U. S. A., and in charge of Mr. W. J. Douglas, engineer of bridges, and Mr. F. A. Perley, assistant engineer. The arches were built by the District Construction Co.

A Legal Aspect of Ground Water is brought into prominence by a bill introduced in the U. S. Senate recently authorizing the City of New York and the Hudson County Water Co. to lay two pipe lines across the Kill von Kull from Bayonne, N. J., to the Borough of Richmond. Some time ago the company made a contract to supply the borough with water from one of the sources controlled by the East Jersey Water Co. interests. The contract was at the rate of $75 per million gallons for the first 3,000,000 gal. and a sum decreasing gradually to $65 per million gallons for a 10,000,000 gal. or more daily. The New Jersey courts prevented the execution of this contract in the manner intended, because there is a law forbidding the diversion of the water of any river, stream or lake to any point outside the State. On the other hand, a supply from driven wells is in the same legal class as oil or natural gas and may be sold outside the State. The Hudson company has begun negotiations with the Board of Public Works of Newark for leasing its driven well plant.

Notes on Water Softening.

A paper read before the Indiana Engineering Society by Mr. W. D. Collins.

The matter here represented is the result of an attempt to find a method of water analysis which might be used by an engineer or other person without chemical training, who wished to determine the treatment necessary to soften a hard water. Since most people are familiar with soapsuds and the practice of the soap method for removing the hardness of the water, an attempt was first made to use a method outlined by Stromeyer & Baron. According to this method the temporary hardness was determined by titrating with an acid, using methyl-orange indicator; the excess of carbon dioxide by titrating with sodium carbonate, using phenolphthalein indicator; the total hardness by soap, and the hardness with soap after precipitating the calcium by ammonium oxalate. After spending much time in the vain effort to obtain satisfactory results from this method, the writer was forced to the conclusion that for him it had almost no value.

After considerable study of methods of determining the necessary treatment for a water, the conclusion was reached that an engineer without chemical training could spend his time more profitably on something else rather than in trying to find the treatment required by water. After considerable experimenting with different methods of analysis, the one finally put together for use in investigating the action of some softening plants proved to be practically the method recommended by the Committee on Standard Methods of the American Public Health Association.

For convenience, the following set of reactions were assumed. These, in fact, are merely diagrammatic, and represent only vaguely the real occurrences. This is probably especially true of the magnesium reactions. The constituents of the water which need attention are supposed to be mainly, calcium and magnesium bicarbonates, sulphates and chlorides. These, with the carbon dioxide present in the water above that needed to make the bicarbonates, are all the constituents considered in this outline treatment.

If the water is to be softened in the cold, lime must be added.

(a) To combine with the carbon dioxide in excess of that in the bicarbonates:

$$CO_2 + Ca(OH)_2 = CaCO_3 + H_2O$$

(b) To combine with the carbon dioxide of the bicarbonates:

$$CaCO_3H_2CO_3 + Ca(OH)_2 = CaCO_3 + CaCO_3 + 2H_2O$$

$$MgCO_3H_2CO_3 + Ca(OH)_2 = CaCO_3 + MgCO_3 + {}''H_2O$$

(c) To combine with all the magnesium carbonate ($MgCO_3$) supposed to be formed in the other reactions:

$$MgCO_3 + Ca(OH)_2 = Mg(OH)_2 + CaCO_3$$

(d) Sodium carbonate (soda ash) must be added to precipitate as carbonates the magnesium and calcium present as sulphates or chlorides:

$$CaSO_4 + NaCO_3 = CaCO_3 + Na_2SO_4$$

$$MgSO_4 + Na_2CO_3 = MgCO_3 + Na_2SO_4$$

The magnesium carbonate ($MgCO_3$) written above is almost certainly not precipitated as $MgCO_3$ but as a basic carbonate, which, however, requires an additional equivalent of lime for its removal just as if the reactions really occurred, as written.

In actual practice with most natural waters, if treatment is applied according to the scheme a satisfactory softening is obtained.

The methods of determining the constituents are as follows:

Excess Carbon Dioxide.—Titrate 100 c.c. of the water with N/50, sodium carbonate free from bicarbonate, using phenolphthalein indicator. The number of c.c. used multiplied by 10 gives the parts per million of calcium carbonate equivalent to the excess of carbon-dioxide in the water.

Temporary Hardness.—Titrate 100 c.c. of the water with N/50 sulphuric acid in a 200 c.c. graduated flask using methyl orange indicator. The number of cubic centimeters used multiplied by 10 gives the number of parts per million of calcium carbonate corresponding to the temporary hardness.

Magnesium.—Heat to boiling in the 200 c.c. graduated flask the 100 c.c. of water neutralized in the determination of temporary hardness. Boil for 15 minutes, add 25 c.c. saturated lime water and allow to stand on the water bath fifteen minutes. Fill to such a height that the volume at room temperature may be 200 c.c. Filter into a graduated cylinder and reject the first 50 c.c. of the filtrate. Titrate the next 100 c.c. with N/50 sulphuric acid, using methyl orange indicator. At the same time make the same determination using distilled water in place of the water to be tested. The difference between the titration for the distilled water and the titration for the hard water is the amount of sulphuric acid which would have been neutralized by the calcium hydroxide which has precipitated the magnesium from the water. This number of c.c. multiplied by 20 gives the parts per million of calcium carbonate, equivalent to the magnesium in the water.

Permanent Hardness.—Boil in a porcelain dish 250 c.c. of the water, add 25 c.c. of N/10, "soda reagent," (equal parts of sodium hydroxide and carbonate), and boil for ten minutes. Filter, make up to 250 c.c. and titrate 100 c.c. with N/50, sulphuric acid, using methyl orange indicator. At the same time make the same determination using 250 c.c. of distilled water instead of the water to be tested. The difference between the titration for the distilled water and the titration for the hard water, is the amount of acid equivalent to the soda reagent used up by the permanent hardness of the water. This number of c.c. multiplied by 10 gives the parts per million of calcium carbonate corresponding to the permanent hardness. In the case of water containing sodium carbonate the water will give a higher titration than the blank, giving a negative permanent hardness. In this case the difference between the two titrations multiplied by 10 gives the parts per million of calcium carbonate equivalent to the sodium carbonate in the water.

Since one equivalent of excess carbon dioxide, one equivalent of temporary hardness or one equivalent of magnesium requires one equivalent of calcium oxide for its removal from the water, .56 times the sum of the calcium carbonate equivalent of excess carbon dioxide, temporary hardness and magnesium represents the number of parts per million of pure lime (CaO) necessary to remove these difficulties 1.06 times the calcium carbonate equivalent of the permanent hardness is the number of the parts per million of sodium carbonate (Na_2CO_3) necessary to remove the permanent hardness. .0083 times the quantities in parts per million gives the pounds per thousand gallons, needed. The results above are for pure CaO and Na_2CO_3. Commercial lime and soda ash must be analyzed to determine the amounts of pure CaO and Na_2CO_3 which they contain.

The advantage of this method of analysis is that the determinations of magnesium and permanent hardness are made by reactions almost identical with those which occur in the softening of the water. In a plant where the strengths of the lime and soda ash used were determined by titration with the same acid used in the analysis the strength of the acid would have no effect upon the correctness of the results. As blank determinations are made in the magnesium and the permanent hardness determinations, variations in strength of the lime water and soda reagent solutions are of no consequences.

Examination of a Treated Water.—If the water has been under treated, it is possible to determine as with an untreated water the amounts of lime and soda still needed to soften the water. In case an excess of soda ash has been added the permanent hardness will be negative and if the water has no sodium carbonate present originally, 1.06, the negative permanent hardness expressed as parts per million of calcium carbonate is the amount of excess of sodium carbonate present in the water. In most cases a treated water is alkaline to phenol-phthalein, in which case titrate 100 c.c. with N/50 sulphuric acid to the end point with phenolphthalein and then on to the end point with methyl orange.

If the amount of acid needed to give the end point with phenolphthalein is more than half that needed to give the end point with methyl orange, an excess of lime is present. If the difference between the two quantities is subtracted from the number of c.c. used to the phenolphthalein end point and the result multiplied by 10, we have the parts per million of calcium carbonate equivalent to the excess of pure lime CaO. This equivalent multiplied by 0.56 gives the parts per million of CaO and this result multiplied by 0.0083 gives the amount in pounds per 1,000 gal.

The calculations given for soda ash and lime are made on the assumption that the water is to be treated cold, which is of course the way it will have to be treated for laundry purposes, or in case it were done on a large scale as by a city water works. For many purposes a water can well be used which is not softened to the limit of the solubility of calcium carbonate.

In case the water is treated in the boiler it will not be necessary to add all the lime as the heat of the boiler will usually precipitate the bicarbonates in a fairly flocculant condition in case there is no calcium sulphate to bind these together. If soda ash is added to the water in the boiler, the sulphates will be precipitated as carbonates and unless the water contains a considerable amount of magnesium, there will be no scale formed. In this case the sludge is all precipitated in the boiler and has to be removed by rather frequent blowing off. In case a feed-water heater is used which brings the temperature of the water nearly to the boiling point, most of the magnesium and calcium present as bicarbonates will be precipitated by the heat. The addition of soda ash to the water as it passes through such a heater will usually precipitate the sulphates and give a water which will form no scale in the boiler.

In order to try the effectiveness of these methods of analysis and to procure some data on the operation of various kinds of softening plants, the writer was enabled through the kindness of Mr. R. P. King to obtain samples from a number of different types of plants in Indianapolis. Samples were taken of the untreated water and the treated water, and in some cases of the water at different stages in the treatment.

Water was obtained directly from one boiler in which a boiler compound was being used. Water was obtained from the boilers in two plants in Richmond where a compound in the form of a saturated solution was added to the feed water as it passed to the boiler. At one plant water was taken from a feed-water heater which was raising the temperature of the water to about 210° F. In this plant soda ash was fed into the water as it passed into the feed-water heater. Samples were taken from three plants where by the addition of lime and soda ash the water was softened in the cold.

The Indianapolis boiler in which the compound was used showed greater permanent hardness in the water in the boiler than in the untreated feed water. This was probably due to the concentration of the water by evaporation.

One of the Richmond boilers contained a water free from permanent hardness and therefore not likely to form any bad scale. The other Richmond boiler showed a permanent hardness in the boiler about one-third that of the untreated water. The engineer said they were using about the same amount of compound for three boilers that they had used when two boilers were run.

The plants softening the water in the cold showed the removal of the temporary hardness to as great an extent as can well be accomplished. In two cases slight excesses of sodium carbonate and lime appeared in the softened water. The other showed a slight permanent hardness remaining.

The plant using soda ash fed into the heater gave a water containing over 400 parts per million of Na_2CO_3. There would be no permanent hardness and the temporary hardness was also reduced to almost nothing. The engineer said that the boiler after two years of use had a coating of scale about as thick as a postal card.

These results, while only a very few, indicate that these waters are being treated in such a way as to give a satisfactory softening in most cases.

One reason why the matter of water softening has not advanced more than it has up to date is that almost any water can be improved by adding lime or soda. A number of other things can be added to the water to improve it. A water which has been greatly improved in its quality would please the user so much that he would not be inclined to question whether the water could not be still more improved by a more careful treatment. Thus the manufacturers and sellers of boiler compounds have prospered.

The results obtained from examinations of some of these waters make of some interest the results obtained by C. H. Chubb and F. W. F. Arnaud. They treated pieces of iron with distilled and river waters containing different amounts of chemicals, sodium carbonate, calcium hydroxide, etc., and determined the amount of iron removed from the pieces in 24 or 48 hours. Their experiments were conducted at room temperature and 100° at atmospheric pressure. They found in most cases first a decrease of action and then as more of the chemical was added an increase and finally a decrease to none. With river water 600 parts per million of sodium hydroxide, 550 parts per million of calcium hydroxide, 2,120 parts per million of sodium carbonate gave no action on the iron.

With distilled water the point at which no action occurred on the iron was reached sooner. This of course would be accounted for by the fact that in the river water part of the chemicals added would be used in precipitating the lime from the water. Experiments of this nature performed under actual boiler conditions of temperature and pressure would surely be of considerable value to persons using softened water for a boiler.

In case the water is to be treated for laundry or other manufacturing purposes, besides the generation of steam it is obvious that the softening must be done in the cold by the use of lime and soda ash. In the case of a large power plant this method is probably the best for the softening of boiler feed water. In the case of a small plant the use of a compound added to the feed water and applied in quantities proportional to the quantity of water, will produce with most waters a satisfactory softening without the expense of the lime as the heat in the boiler accomplishes most of the softening that would be accomplished by the lime. In the case of a plant of any size using a feed-water heater which brings the temperature of the water nearly to the boiling point, the water can be softened in a most satisfactory manner with no extra apparatus, except the device for feeding the proper compound, often plain soda ash, to the water as it enters the heater. In this case the sludge must be removed from the heater instead of having to blow off the boiler as is done where the compound is added to the water in the boiler. On account of the concentration in the boiler it is necessary to blow off occasionally to prevent foaming, but this will not be needed nearly as often as where the compound is added to the boiler.

Thus it would seem that except in the case of rather remarkable waters there is no reason except carelessness for having any considerable amount of scale formed in a boiler.

Iron and Steel Exports from the United Staes have increased 75 per cent. in three years, according to the Bureau of Statistics. Last year their value was $172,555,588; in 1896 the same class of exports was worth but $48,670,218.

Experience With Steel Sheet Piling in Hard Soils.

Steel sheet piling has been used to a considerable extent on work constructed under the direction of Mr. Wm. G. Fargo, and at the recent meeting of the Michigan Engineering Society he read a paper giving some of his observations of the action of this material when driven in hard soils. Its usefulness in soft material has been well demonstrated, but data relating to its service in soil which offers a considerable resistance to driving are so few that the following notes are reprinted from the paper. In selecting sheet piling for such a purpose he advises paying special attention to its water-tightness and stiffness, two properties he discusses as follows:

In deep coffers a prime requisite is water-tightness, and the clearance of interlock must, therefore, be reduced as much as possible to allow driving. The clearances used on the fabricated types of piling are from 1/8 to 1/4 in. all around the interlock. In hard soils 1/4 in. is none too much. In many sections of piling over 15 or 20 ft. long, there will be found such kinks and crimps, partly the result of handling on and off cars, that driving with a tight interlock is a serious problem, the pile often refusing, with such a close interlock not true or perfect in alignment, when there is encountered in addition a stratum of hardpan or a layer of small boulders. Under such conditions, piling often refuses under the heaviest drop or steam hammer. If driving is persisted in, crippling of the pile either at the top or bottom will result. Crippling at the bottom means usually an escape from the interlock and a curving to one side exactly like that of a clinched nail except that the curve of the clinch may have several feet radius.

Cofferdam of Steel Piling at the Croton Dam of the Grand Rapids-Muskegon Power Co.

In locations where strata of hard material are encountered, such as often occur in river valleys where the drift has been eroded and re-deposited, the steel piling, to be a success, must possess considerable stiffness laterally to prevent crippling. It is Mr. Fargo's experience that the free or unengaged edge of the pile that is being driven should, for hard driving, be of a width at right angles to the web from one-third to one-half of the width of the engaged web.

The friction of long lengths of steel piling with the inevitable crimps will make necessary a heavy hammer, say a 4,500-lb. ram on a steam rig, or a 3,000-lb. or heavier drop hammer. Most of Mr. Fargo's experience in driving steel sheeting has been with the heaviest Vulcan steam hammer having a 4,500-lb. ram. The total weight of the hammer resting on the pile is 10,000 lb. These hammers are adjusted to strike about 65 times per minute with a 3½-ft. stroke.

These large Vulcan hammers are preferably fitted with a McDermid base, consisting of a circular steel plate about 13 in. in diameter by 1⅜ in. thick. These plates are slipped into a slot in the base of the hammer housing and receive the blow of the ram. The wood striking block or cushion is set into the heavy cast-iron follower on the pile and projects up into the socket of the hammer housing so that the McDermid base plate rests directly on the wood blocks. These wood blocks are made about 20 in. long, 15 in. in diameter at the center, and hewed to about 12 in. at the top and bottom to enter respectively the hammer housing and the follower.

In driving through hard clay layers or when the piling is bound slightly by crimps in the interlock, the blows of such a hammer may run as many as 30 to 60 to the inch of penetration. In hard driving one or two fresh blocks per 30-ft. pile are often required. The time consumed in stopping and changing blocks is from two to five minutes, provided the block is not badly split and wedged in. It is necessary to watch the failure of these blocks closely, as with a crushed or broomed block the efficiency of the hammer is very low. The crushing usually takes place toward the middle of the length of the block, making a hot, steaming pulp of the tough oak or maple fiber for a length of 3 to 5 in. Partially seasoned swamp oak, rock maple and blue gum have given Mr. Fargo the best service.

In driving steel sheet piling, if the alternate sections are light and heavy, i. e., having double webs or double Z bars, a heavy section should be driven first, going slowly and taking great care to have the initial pile plumb and exactly in position. A light section is then interlocked. On account of the time consumed in cutting off steel sheeting weighing 30 to 54 lb. to the square foot, it is always desirable to back the driver away from the work. In close quarters approaching a wall, or in the end of a deep cut for a core wall, for instance, this is not always practicable.

Borings in casing are made along the proposed line of steel sheeting at say 25 ft. intervals, and the steel ordered to length accordingly. Except when encountering rock, boulders or extremely tenacious hardpan, the piles can usually be driven to a fairly uniform top level. When the objective foundation soil or rock bottom is in an eroded river valley which has again been refilled with drift, the hard bottom will frequently be covered with a generous strata of boulders which have dropped out of the eroded material because too heavy to be washed down stream. This boulder stratum is, of course, quite irregular and not so desirable a material in which to terminate sheet piling as a good clay or slightly disintegrated rock covering sound bed rock. Often, too, sound bed rock is deeply channeled and filled with pot holes so that piling may need some cutting, if it cannot extend above grade as into concrete.

In passing a line of steel sheeting around a boulder of large size, special angle or bent piling sections are desirable to make the departure from and return to the line as planned. Some of the types of sheeting adapt themselves readily to such changes of aligument without using special pieces. Bending a ⅜-in. or ½-in. web longitudinally to a short radius in the field is not an easy matter.

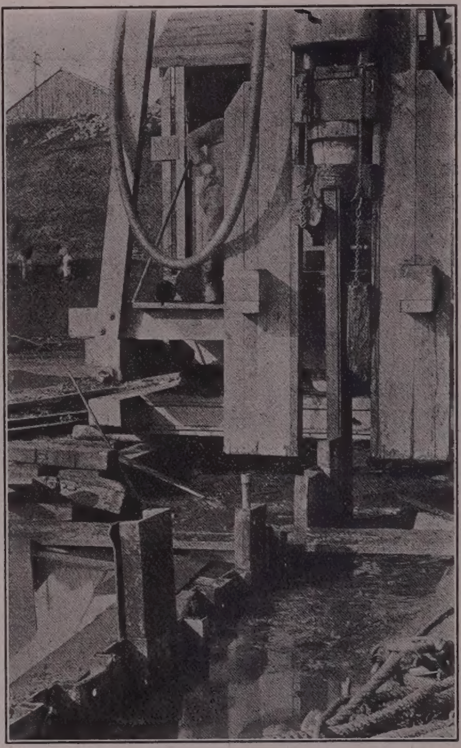
When using rigid non-reversible interlocked piling in quicksand and on work of such character that close water-tightness is required, special corner pieces should be kept on hand for emergencies. In some soils it may be permissible at times to turn corners by driving outside the interlock and tight against a projecting flange, placing the new piling at any angle required. Sometimes it may be feasible to fill gaps and make closures with specially prepared squared wood piles, with points beveled to make the wood piling hug the steel.

In hard driving among stones only a type of piling of great stiffness laterally and with perfect interlocking features will insure success. On such work there must be no alternate unstiffened sections of piling. The interlock must be perfect and confining, difficult to open up and permit the escape of the inside member. Even with the heaviest and most confining type of interlocked piling now on the market in this country, this opening of interlock will sometimes occur when boulders are encountered.

Small boulders in gravelly soils are usually displaced without trouble. Sometimes the aid of a jet is a help. Usually steel piling will drive easy enough in ordinary soils without a jet. In hard clays a jet is not of much assistance and is very slow. Obviously it is not often required to drive steel sheeting far into hard clay.

In driving four lines of steel piling across the valley of the Muskegon River in Mecosta and Newaygo Counties, Mich., the borings showed "floating" masses of clay hardpan sometimes several hundred feet across, and from 1 ft. to 12 ft. thick. Below was quicksand before reaching a bed of hardpan continuous across the valley; hence the necessity for driving through the floating hardpan. The hardpan in question consisted of about 70 per cent. of bluish clay, and 30 per cent. of sharp sand, well mixed and compacted by water deposition and pressure, to the texture of frozen soil. In this hardpan were stones from gravel up to boulders of 5 tons weight. This material cost $3 per cubic yard to trench, and angular fragments would lie for months in water moving with a velocity of 5 ft. per second without material erosion or change in form. Lubricating the piling with grease before driving, and with a stream of water under pressure when driving, seemed to be of no special aid in the hardpan mentioned.

On the Big Rapids dam of the Grand Rapids-Muskegon Power Co., the single-channel sections of Friestedt piling frequently buckled and recourse was then had to double Z-bar sections entirely. This piling with two Z's on all pieces weighs about 54 lb. per square foot, and to reduce the weight Mr. Fargo had a single Z-bar riveted to every channel instead of using double Z-bar channels exclusively, or alternating with plain channels. The single Z-bar to every channel allows the free or uninterlocked edge of the pile being driven to be stiffened by a Z-bar. On this type, Mr. Fargo has obtained a patent and has used over a thousand tons so made with satisfactory results, nearly all driven into hard soils.


Base Plate, Cushion and Follower.

The manufacturers of piling place much stress on easy pulling, but in his experience in hard soils Mr. Fargo has never been able to get jacks enough on a piece of steel piling 12 ft. in the ground to pull it. In soft river mud or silt, pulling with heavy tackle can be done. Probably a hammer striking upward blows in manner similar to that used in pulling pipe casings from test bore holes would be operative except in cases of badly crimped and bent piles.

The cost of driving piling 13¼ in. net width with a steam hammer on the Muskegon River work mentioned ran from 7¼ to 20 cents per lineal foot in place. The 7¼-cent cost was on land in sand and gravel with some clay strata; the piling was 20 to 40 ft. long.

The average amount of piling driven per hour in fairly good ground is 40 to 50 lin. ft., including the time of moving the driver. In general the cost per square foot for driving steel sheeting is 25 per cent. less than for driving wood.

The longest single length driven on Mr. Fargo's work was 44 ft., but spliced lengths up to 58 ft. have been successfully used. In doing "spliced" work it is not necessary to actually bolt or rivet the splices, the procedure being to use two lengths so as to break joints in the interlock.

The Specific Gravity of Portland Cement

The specific gravity of Portland cement has long been considered a test of its quality, and is specified as such in the recently issued British Standard Specification. It is held to denote the degree of calcination to which the cement has been subjected in the course of manufacture, a high specific gravity indicating a thoroughly burned material, and vice versa; it is also considered to indicate adulteration with materials of different specific gravity.

It is well known that, owing to absorption of water and carbonic acid (having specific gravities of 1.0 and 0.88 respectively), the specific gravity of cement decreases with age, or after aeration, but Mr. David B. Butler was surprised to find that, after ignition at red heat to expel the water and carbonic acid and to reduce the material to practically the same condition as regards these substances as when it left the kiln, the specific gravities of various cements were so nearly identical as to render the test of little or no value as an indication of quality. He recently submitted a paper on the subject to the Institution of Civil Engineers, which has published the abstract of it that is reproduced in this article. The results of preliminary experiments with thirty different cements, having specific gravities varying between 3.026 and 3.138 (*i. e.*, a difference of 0.112), showed that after ignition the specific gravities differed by only 0.016, which is well within the range of experimental error in ordinary technical determinations.

In order to test the general accepted theory that specific gravity is an indication of the degree of calcination, 28 samples of black well-burned and yellow under-burned clinker from the same kiln or charge were obtained from various works, and the specific gravity of each sample was ascertained (1) in the condition in which it was received, and (2) after ignition at red heat. The results showed that all the yellow under-burned samples, when they had absorbed any appreciable amount of water and carbonic acid, had a much lower specific gravity than the well-burned samples, but that after ignition at red heat the specific gravities of the well-burned and under-burned materials were practically identical, indicating that the difference was merely due to absorption of water and carbonic acid.

A notable fact in connection with this series of experiments was that, out of 13 samples of yellow under-burned material fresh from the kiln, no less than eight would have fulfilled the requirements of most ordinary specifications for well-burned cements, as regards specific gravity. The subject was therefore investigated further, and instead of merely ascertaining the total loss on ignition before determining the specific gravity, the percentage of water and carbonic acid was estimated separately. This was done with 41 different cements, which were not in any way specially chosen for the purpose, but were ordinary samples passing through the author's hands in the usual course of his practice. The samples were afterwards classified for more convenient reference, and comprised English, Belgian and German artificial Portland cement; Belgian natural cement; cement produced by the lately introduced rotatory kilns; and also cement adulterated with various adulterants. In all these experiments the result was practically the same. Samples which in their commercial condition differed widely in specific gravity, were found to have practically the same specific gravity when "loss free," *i. e.*, after ignition at red heat, and consequent expulsion of the water and carbonic acid absorbed since calcination.

The main body of the experiments having been made with ordinary commercial samples containing comparatively little water and carbonic acid, additional experiments were made with two cements of first-class quality, which had been exposed to the atmosphere for 80 days, during which period they had been periodically examined, and had finally absorbed water and carbonic acid to the extent of about 10 per cent. altogether. The result was the complete corroboration of previous experiments, showing as before that the specific gravity depended entirely upon the water and carbonic acid absorbed, which could be exactly allowed for by calculation.

These experiments having been conducted in a somewhat more careful manner than those first described, it was thought advisable to verify the results obtained in the first instance with well-burned and under-burned clinker, and further samples, 23 in number, were therefore obtained, representing practically the entire English cement industry. The results fully corroborated the previous experiments in every respect, and fully demonstrated the fact that the degree of calcination in no way affects the specific gravity when the clinker is fresh from the kiln.

Having regard to the difference in apparent density and weight, between the black well-burned and the yellow under-burned clinker, the porosity of small pieces of each degree of calcination was determined, and showed that the porosity of the yellow under-burned clinker was 66.65 per cent., of the intermediate clinker 57.2 per cent., and of the well-burned clinker 22.6 per cent.; in other words, 9 parts by volume of yellow under-burned clinker become on further calcination 7 parts of intermediate and 4 parts of well-burned clinker.

Briefly summarized the conclusions which may be drawn from the experiments are:

(1) That the specific gravity of Portland cement is no indication whatever of proper calcination.

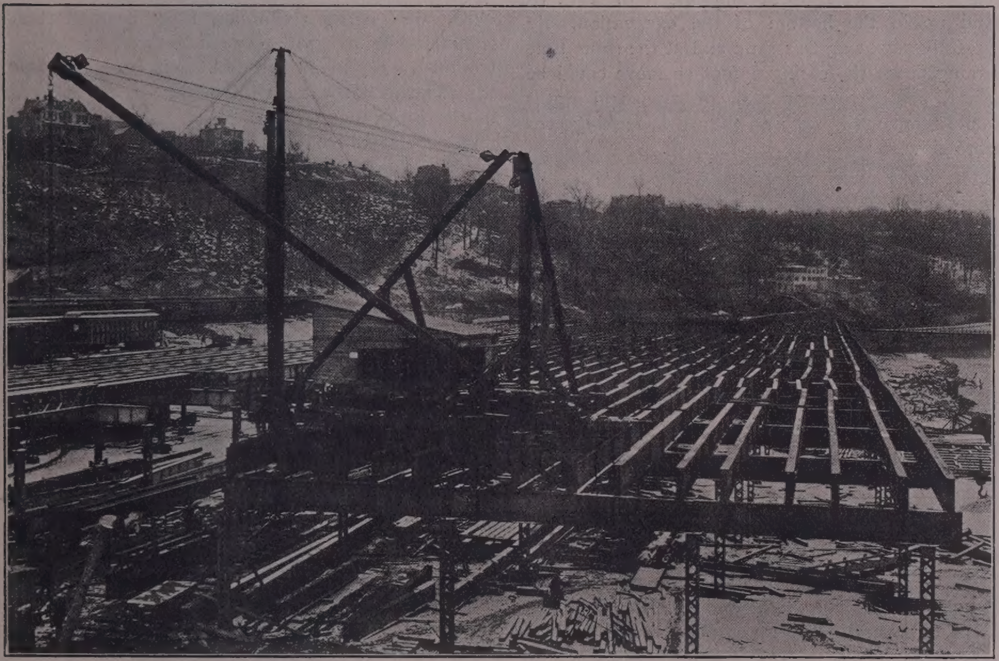
(2) That the specific gravity of Portland cement depends upon its age, and the opportunities which it has been afforded of absorbing water and carbonic acid from the atmosphere.

(3) That the specific gravity of Portland cement, although of no use in determining calcination, may sometimes be of corroborative value in determining slag and other adulteration.

(4) That, given the specific gravity of the ignited sample, and the percentage of water and carbonic acid expelled by ignition, the specific gravity of the unignited material may be calculated with a fair degree of accuracy.

Building an Elevated Railroad Yard.

The extension of the yards of the Interborough Rapid Transit Co., at 159th St. and Eighth Ave., New York, occupies an area of 300 ft. wide and 800 ft. long with about seventeen parallel storage tracks carried on transverse and longitudinal girders of regular spans up to about 65 ft. at a clear height of from 15 to 25 ft. above the surface of the ground. The superstructure, exclusive of several hundred tons of new stringers, is chiefly composed of girders previously used on some of the Brooklyn elevated railroad lines, which were brought to the yard and there remodeled to fit the new work without, in most instances, being sent to the shops. Some of them had to be shortened and others were reinforced, while nearly all of the connections for the bracing were made and most of the transverse and lateral braces cut and riveted to fit, some of the latter work being done, however, at the contractors' shops.


Derrick and Portion of Yard.

An Ingersoll-Rand air compressor with a capacity of 500 cu. ft. per minute, operated by steam from the Interborough Company' plant, four Watson-Stillman and Dudgeon punches, twelve pneumatic drills, six chisels and ten hammers of the Chicago type were installed at the site, and the 3,000 tons of steel was refitted there and erected in about 200 days. About 150 tons of transverse swaybracing was riveted up at the shops, where the only other material finished for this work was such as required to have the ends faced. In general, the foundations were made to suit the varying lengths of the columns, but in some cases the latter were cut to suit in the field.

The steelwork was unloaded, handled and stored by a guyed derrick which reloaded it on service cars delivering to the overhead traveler by which it was erected. The traveler was a stiff-leg derrick with 10 x 14-in. horizontal sills mounted on two wheels under the mast and single wheels under each outer end, 28½ ft. distant, and traveling on a track of 30-ft. gauge. The stiff-legs were single 10 x 12-in. timbers, pin-connected at the bottom. The mast and boom were 14 x 14-in. timbers 29½ ft. and 64½ ft. in length respectively, and with Terry standard forged and cast steel fittings. The boom had a capacity of 10 tons and was rigged with two four-part steel rope tackles operated by a Lidgerwood hoisting engine with an attachment for revolving the 12-ft. bull wheel at the base of the mast.

The steelwork was erected by three trips of the traveler, moving back and forth longitudinally and assembling from 75 to 100 ft. of the width of the structure each time. When it was necessary to shift from one track to another, the sills were jacked up and transverse rails placed under them on which it was skidded across to the required position and lowered to the new track in a very short time. The boom, being located at the corner of the horizontal framework, could swing about 270 deg., and was able to reach back and take up the rails in the rear of the traveler and relay them in front of it in successive lengths as the erection advanced. It was operated by six men and handled the steelwork conveniently and expeditiously.

The work was executed under the direction of Mr. George H. Pegram, chief engineer. The Terry & Tench Co. was the contractor, and Mr. T. W. Cartledge was in charge.

Some Remarkable Underpinning.

Some remarkable underpinning is being done below the foundations of the retro-choir and lady chapel of Winchester Cathedral in England. A gradual settlement of this portion of the structure has been taking place for four centuries, and of late the results have become serious. Cracks have appeared in the masonry, walls have moved from the perpendicular, and two bad cracks have occurred in the roof. The trouble is due to inadequate foundations and insufficient buttressing. The footings rest on a grillage of beach timbers packed with chalk and flint, which is carried by a thin sheet of soft marl only 10 ft. below the surface. Below it is a bed of soft peat and gravel 6 ft. thick which rests on good, hard gravel. The peat is full of water and its presence is the probable explanation of the original failure to carry the footings to the hard gravel. Under the direction of Mr. T. G. Jackson, the underpinning is being done in small sections. A hole is sunk close to the wall down through the peat and then a heading is driven under the old footing and the old timbers are removed. The lower part of the pit is sunk by a diver, as the water is too deep for ordinary methods of working, and it would be dangerous as well as very costly to pump the water out. When the hard gravel bed is reached, the diver covers it with concrete delivered to him in bags, which he slits open. After a few feet of concrete have been placed in this way, grout is forced into it through pipes. The concrete is carried up in this manner to such a height that masons can complete the underpinning with brickwork.

The Cost of Colorado Roads is discussed in a recent bulletin of the Agricultural Experiment Station, at Fort Collins, Colo. Complete reports were received from the county clerks or the county commissioners of 27 of the 59 counties of the State. These reports cover a total of 9,226 miles of county road with an expenditure of $375,003.51 during 1905, an average of $40.64 per mile. The reports also show a steady increase in the amount expended each year, the sum for 1905 being almost double that for 1900.

Sinking and Lining a 6-ft. Well 80 ft. Deep in Water-Bearing Soils.

The excavation for a well 6 ft. in diameter and 80 ft. deep, for a shot tower built for the Equitable Powder Co., of East Alton, Ill., was recently made in sand, gravel and clay which carried large quantities of water, and a perfectly waterproof concrete lining provided for it under particularly difficult conditions. The works of the power company are two miles from the Mississippi River, but owing to the many and varied strata of sand and clay encountered in the excavation, it is considered that the course of the river was at one time over the site. A test hole put down at the latter to a depth of 40 ft. with a 2-in. pipe determined that about 10 ft. below the surface was a stratum of sand, 6 to 8 ft. thick, which changed gradually into coarse sand and gravel containing a large amount of water. Under this sand and gravel was a bed of blue clay followed in order by strata of fire clay, quicksand and then clay again.

A well with a clear diameter of 6 ft. being necessary, and a 9-in. concrete lining having been adopted, an excavation at least 7.5 ft. in diameter had to be made. The nature of the materials to be passed through was considered to be such that a one-piece casing of constant diameter could not be forced down. Accordingly the casing was made in eight vertical, cylindrical sections built of 5/16-in. boiler plate. Each of these sections had a 1½x3-in. reinforcing ring at the top and bottom, the top ring being riveted to the outside and the bottom ring to the inside of the casing. The section at the top was 10.5 ft. in diameter, the next one below it, 10 ft. 1 in. and so on, each section differing by 5 in. from the previous section in order that the various sections could be telescoped and the joint between the reinforcing rings caulked with oakum. Each section was prevented from sliding down over the one below it by ½x3-in. angles bolted to it; these angles also locked the sections together.

The first and second sections were put down without any difficulty, the excavated material being taken out in buckets raised to the surface by a hoisting engine, and the water encountered discharged by a steam siphon. The real difficulties were first encountered in sinking the third section when the water began to flow in such quantities that the siphon could no longer handle it, so a 500-gal. duplex pump was installed. This pump was set on a platform swung at the bottom of the excavation on a wire cable suspended over a chain block at the top of the well, enabling the platform to be lowered or raised as desired. The pump could only just handle the water that flowed into the excavation from the coarse gravel encountered in sinking the third section. The sinking of the last few feet of the latter was in clay and was accomplished without difficulty.

In sinking the fourth casing, however, work was nearly stopped when the cutting edge entered a bed of quicksand. The section was finally forced through the quicksand with eight jack-screws spaced equally around the rim. After penetrating about 18 in. into the clay below the quicksand, the power afforded by these jack-screws was found to be inadequate to force the shell down further, so this section was left 1 ft. above its proper place. By this time the water had been nearly shut off by making the excavation slightly smaller than the ring, the remaining clay forming an almost watertight joint. During the sinking of this and all the subsequent sections the joints between the latter would occasionally break loose and until they could be caulked again large volumes of water carrying sand and clay would pour into the excavation. This caulking could only be done with great difficulty as the leak would travel around the casing and force out the oakum in fresh places. The joints could not be made tight enough so they could be poured with lead and no other means could be devised to make them dry enough to permit concrete to be deposited against them, for of course the smallest leak would have washed out the green cement.

The large horizontal pump was found to be unsuited to the work, so a vertical outside-packed plunger pump with a capacity of 33 gal. a minute was secured. At this time there was a leakage of only 5 to 6 gal. a minute which came through the joints or followed down the outside of the casing and came in at the bottom. Good progress was made for a time under these conditions, when suddenly a stream of water forced its way up through the clay in the bottom and the large pump was placed in service again. The last clay was removed 10 to 12 ft. below this break, leaving a bed of sand carrying a heavy flow of water. After considerable difficulty with the pump the casing was forced down by working the jacks and excavating the sand simultaneously. After sinking the section 7 or 8 ft. in this manner the pressure on the outside of the casing caused the water to gush forth and pile 3 or 4 ft. of sand up in the bottom of the excavation. By carefully removing this sand and at the same time forcing down the casing a foot or more could be gained before another rush of sand and water would temporarily suspend the work, making progress slow.

The leaks which occasionally developed at the joints had meanwhile carried so much sand and clay into the excavation that the surface of the ground had cracked and settled over an area 40 ft. in diameter around the mouth of the well. This sinking finally became so marked that the decision was made not to go any lower, for although the last section had not been put down an extra 7 ft. of depth was gained by the settling of the ground at the surface. Before preparations could be made to build the concrete lining, however, a heavy flow of water broke through between the fourth and fifth sections and the subsequent movement of the soil around the casing squeezed the latter to an egg shape. Fearing the entire casing might collapse the well was allowed to fill in order to balance the pressure on both sides of the casing. As this occurred late in the fall operations were suspended until spring.

A steam-driven deep-well pump, with a Cook well point, was set up when work was started in the spring, and proved very satisfactory in keeping down the water. When the latter had been removed it was found that about 20 ft. of material had filled in at the bottom of the excavation. As soon as this was removed the sand again began to come in, but the bottom was readily sealed with two layers of sacks of concrete. The water was then permitted to rise in order to relieve the pressure on the concrete while it was setting. When this concrete was hard, the water was drawn down again and 30 in. of concrete laid over that in the sacks. A rectangular opening was left in this floor for the well point on the suction of the deep well pump. This opening was covered with steel plates placed around the well point and a 12-in. concrete floor laid over the whole bottom. A 5-in. threaded pipe fitted with a flange was also placed through the floor to prevent the water pressure coming on the latter if the pump failed. This 5-in. pipe was provided with a blank flange tapped for a 1-in. and a 2-in. pipe which were used later in filling the opening around the well point.

The concrete lining was placed in forms built of 2x4-in. lagging spiked to circular ribs. These forms were made in sections 10 ft. long, the length of each section of the casing, and were built in six segments. New ribs were required for each section owing to the changes in the diameter of the excavation, but the lagging was used repeatedly. The forms were made above ground and the segments lowered into the well, where those of a section could be bolted together and beveled ready for the concrete in 2 to 3 hr.

The angle braces on the casing which were not already sheared off when the water was drawn down in the spring were removed. The joints between the sections were then calked with fresh oakum, and dried white pine tongue and grooved wedges were driven into them with sledges. In spite of these precautions the joints continued to leak so they were covered with strips of tin, leaving a hollow at the joint through which the water was conducted to a pipe leading through the forms.

The concrete mixture consisted of 1 part Portland cement, containing 1½ per cent. by weight of Medusa waterproofing compound, 2 parts of coarse river sand and 4 parts of crushed limestone, which would pass through a 1-in. screen and be held on a ¼-in. screen. Tests of various waterproofing substances, such as a mixture of alum and soft soap and hydrated lime, were made before the work was commenced, with the result that the Medusa compound was adopted. Test blocks of concrete containing 1 per cent. of this compound mixed with cement showed no penetration over 1/16 in. in depth after being soaked for 48 hr. in hot water, while plain concrete mixed in the same manner was found to be saturated under the same conditions.

No night work was done in placing the concrete, but the damp air in the well prevented the latter from attaining much of a permanent set over night, and the surface of the finished work was carefully washed with neat cement each morning. The water was allowed to rise in the well as the concrete was brought up and after the work was finished was allowed to stand for six weks so the concrete would be sufficiently hardened to resist the pressure head that would be brought against it. When the water was pumped out the various pipes that had been left in the concrete to handle the water from the joints in the casing were filled. The compartment containing the point of the pump was finally filled through the 2-in. pipe in the flange on the 5-in. pipe left in the floor. A certain amount of seepage was expected through the lining, but after remaining damp for several months the concrete became as dry as concrete above ground.

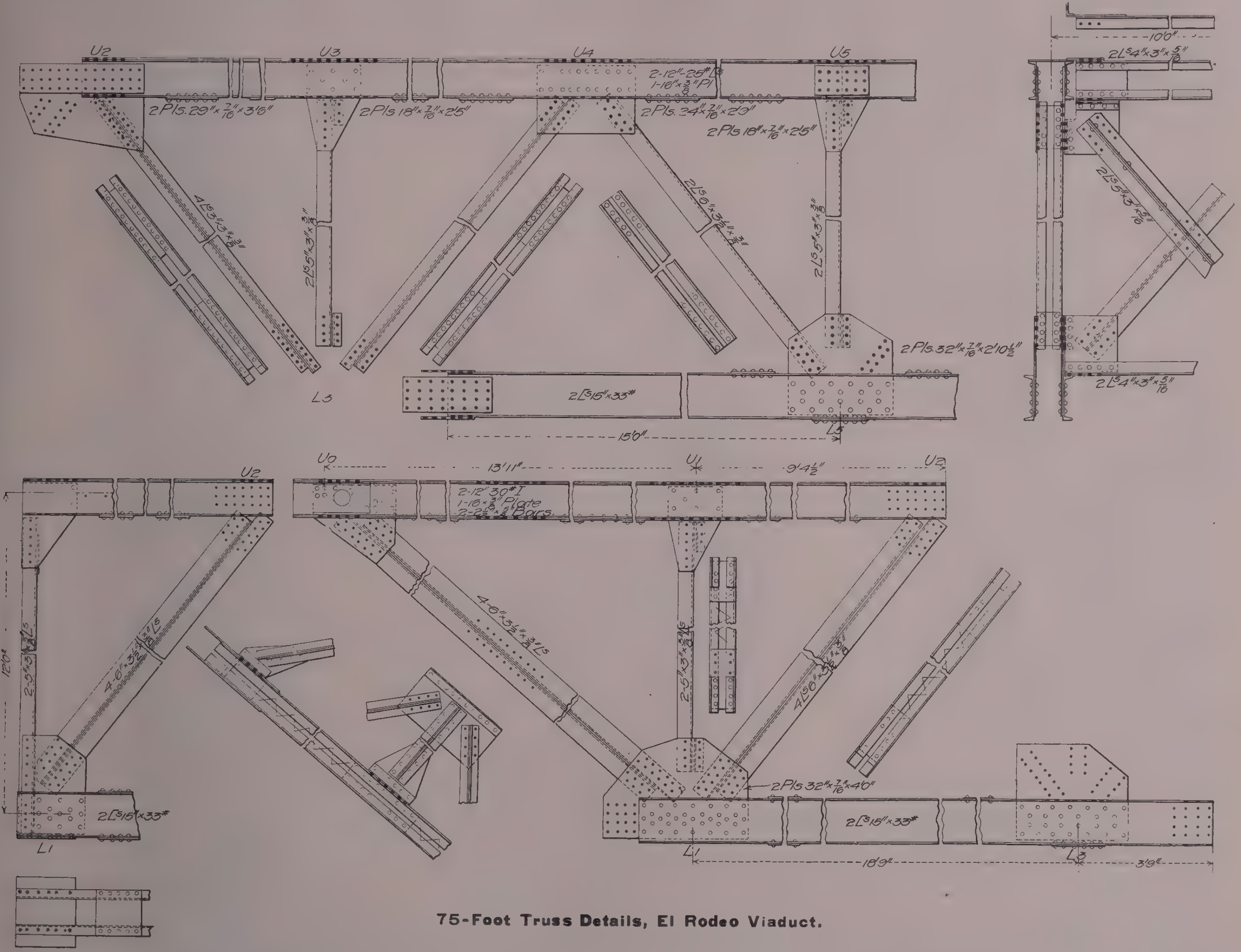
The 2 to 3-in. cracks in the surface of the ground around the mouth of the well were washed full of sand and then a square several feet larger than the footing for the building was excavated to a depth of 14 ft., the upper 6 ft. in sunken ground and the remainder in solid earth. The bottom of the excavation was then covered with sand on which the footing walls and piers for the tower were built, the remainder of the excavation being filled to the ground level again with earth. Elevations determined on the footing walls showed a slight settlement when the full load of the superstructure was first placed on them, but this has now ceased and the tower has not been strained in any way.

The foregoing information was supplied by Mr. W. E. Wagner, who assumed charge of the work during the sinking of the fourth section of the casing.

Excavation in the Culebra Cut of the Panama canal amounted to 566,750 cu. yd. during January, the highest previous monthly record being 325,835 cu. yd. in October. During January 15,604 employes were carried on the "silver roll," 3,881 on the "gold roll," and 4,400 by the Panama R. R. It is reported that the arrival of a considerable number of Spanish and Italian laborers has improved labor conditions.

Viaducts on the Guatemala Ry. at El Rodeo and Station 1132.

The El Rodeo viaduct on the Guatemala Ry. is designed, like the Las Vacas viaduct described in The Engineering Record of Jan. 26, for a present 3-ft. gauge track with provisions for future change to a standard gauge track with the live loads given in the issue of Dec. 8, 1896. Las Vacas is the most important viaduct on the line and resembles it in general construction, but has some special features due to the requirements of the location. It has a total length of 571 ft. on the center line between the back walls of the abutments, and is built from end to end on a 6 deg. curve with a radius of 955.4 ft. It has five towers 30 ft. wide, varying from 19 to nearly 139 ft. in height which, with the abutments, support six spans with riveted trusses 12 ft. deep and 10 ft. apart on centers. The towers are spaced 105 ft. apart on centers, or about 74 ft. apart in the clear, and terminate just below the bottom chords of the trusses which rest on their upper transverse girders.



75-Foot Truss Details, El Rodeo Viaduct.

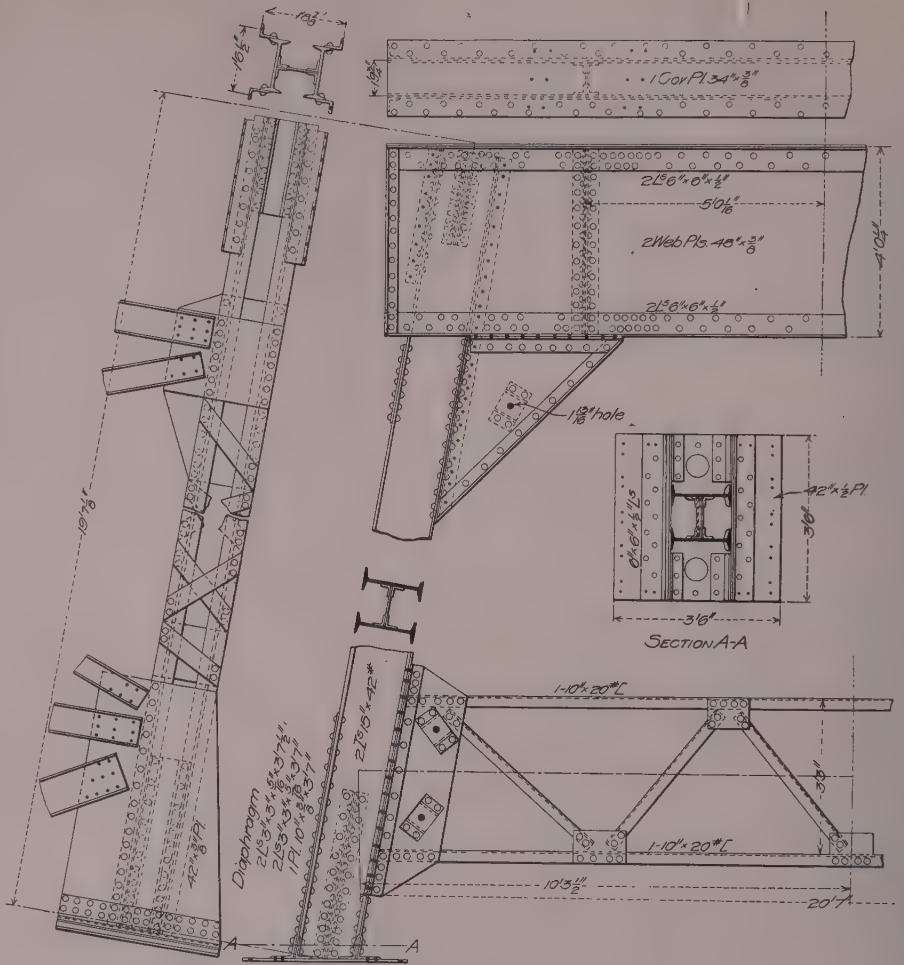
Owing to the exigencies of erection, it was decided to make provision for temporary transverse movement of the trusses on the tower girders. This, together with the oblique angles at which they were seated, made it impracticable to support the abutting ends of two trusses of adjacent spans on the same tower girder; therefore the trusses reach from center to center of the towers and are double cantilevers, symmetrically supported on the tower bents 15 ft. from each end. This arrangement is secured by making the lower chords terminate at the tower bents and continuing the top chords one panel further to make the 15-ft. overhangs. Although it involves the necessity of heavy longitudinal struts at the top of the towers, it effects an economy in the total weight of the structure and greatly simplifies the erection.

The lower parts of the towers correspond to those of the Las Vacas viaduct. The ground is very irregular so that no four of the pier tops are at the same level, and the feet of the columns are generally connected by inclined struts as shown on the diagram, where the dotted lines indicate the members on the side not shown in elevation. The double-web transverse girders at the tops of the bents differ from those in the Las Vacas viaduct in that their ends are not beveled to correspond with the batter of the tower posts but project slightly beyond them and are cut square, thus extending the length of the top of the girder and affording more clearance for the temporary movement on it of the longitudinal trusses. The girders are also different, in that their ends are additionally connected to the columns by solid-web knee-braces with pairs of 4x3-in. flange angles, field-riveted to them and to the posts and provided with bent-plate connections for the pins in the upper ends of the sway-brace rods. The tower posts are all made of two I-beams connected at the upper and lower ends by diaphragms and connected intermediately by tie plates and lattice bars on their flanges. The longitudinal struts are all made of pairs of 9 or 10-in. channels latticed and field riveted through their webs to jaw plates on the column posts. The transverse struts, like those of the Las Vacas viaduct, are virtually light lattice girders with end flange angles field-riveted to the tower posts.

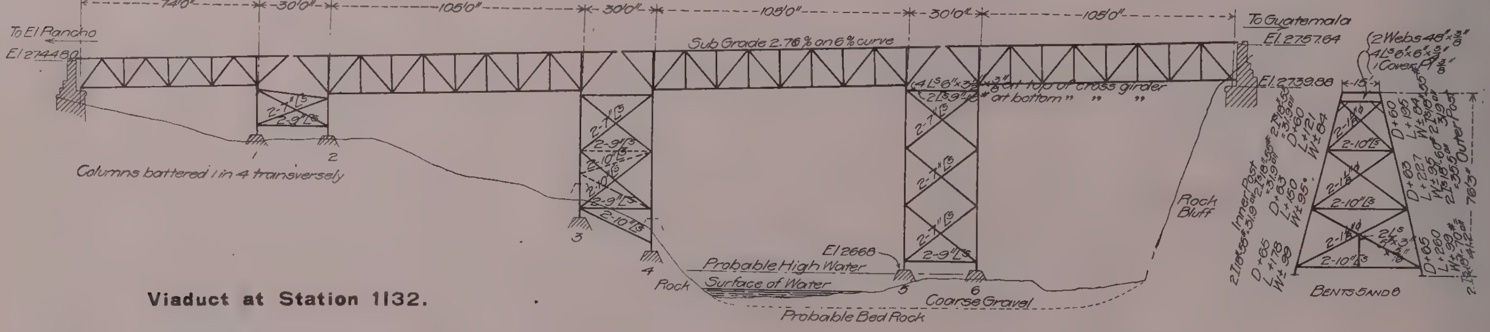
Each truss of the 105-ft. spans is shipped in separate pieces, field-riveted at all connections as indicated in the detail drawings. All connections are made with pairs of jaw plates generally shop-riveted to the webs of the top and bottom chords, and field-riveted to the web members of the truss. The bottom lateral system consists of X-brace angles field-riveted to horizontal connection plates attached to the top flanges of the bottom chords. Similar bracing is provided for the inclined web members in the overhanging panels, and sway-bracing of the usual type is provided at the center of the truss and in the planes of the tower bents. The lengths of the diagonal members in the trusses are calculated to make a camber increasing from 7/16 in. at the second panel points to ¾ in. in the center. The top chords are made of two 12-in., 30-lb. channels and a 16x⅜-in. cover plate, and each is shipped in four pieces. The bottom chords are made of a pair of 15-in., 33-lb. channels latticed, and each is shipped in three pieces. Horizontal 5 17/32-in. pin-holes are bored in the ends of the top chords to provide connections for the erection links. The ends of the end spans are made special with vertical end posts for direct support on the abutments. The shipping lengths of the members, like those of the Las Vacas viaduct, were limited to 30 ft., and the material has been fabricated and shipped by the Baltimore Bridge Co.

Another important viaduct is that at Station 1132. The superstructure is 479 ft. long, and consists of three main spans and one short span seated on three 30-ft. towers 105 ft. apart in the clear. The main spans cantilever to the centers of the towers like those of the El Rodeo viaduct, and are 135 ft. long over all on the top chords. The end spans have one cantilever and one square end supported on the abutment. The short end span is 9 ft. long over all and 12 ft. deep. The main spans are 16 ft. deep and all trusses are 10 ft. apart on centers. The towers have heights of 19 ft., 66 ft. and 69 ft., and like those of the other viaducts are seated on battered concrete piers 5 ft. square at the top. Pairs of horizontal reaction angles 4½ ft. long, are embedded in the concrete 3 ft. below the upper surface and their lower horizontal flanges receive washer plates that afford bearings for the double nuts on the ends of two 2-in. anchor bolts, enclosed in 6x6-in. vertical boxes providing adjustment space which is grouted after the erection is completed.

The axis of the viaduct is on a 6 deg. horizontal curve and has a 2.76 per cent. grade from end to end. The details of construction correspond essentially with those of the El Rodeo viaduct, except that the tower girders are extended a little farther beyond the tops of the posts to provide for the displacement of the trusses and the top longitudinal struts in the towers are made with projecting flange plates extended to engage a large number of field rivets in the flanges of the tower girders. In the tallest tower, the displacement of the trusses during erection is greater than is provided for by the width of the girder, and the latter is extended on one side by solid web brackets in the planes of the diaphragms which connect the webs at the girder bearing. The tower posts have extended bases and are seated on grillages made of five 10-in. I-beams riveted to a ½x45x45-in. sole plate resting on a 1-in. masonry plate. The two spans over high ground at the El Rancho end of the viaduct will first be erected on falsework and will serve as anchor spans for the erection of the two remaining spans which will be erected by the cantilever method, shifting them to different angles in successive stages so as to secure the required alignment when connected together for anchorage purposes.



Tower Details, El Rodeo Viaduct.



Viaduct at Station 1132.

The viaduct was designed by Mr. V. G. Bogue, New York; Mr. W. H. Kennedy and Mr. A. W. Buel, associated engineers on railways and bridges respectively. Mr. S. F. Shaw is chief engineer, and Mr. J. H. Pope is bridge engineer of the Guatemala Ry. The Baltimore Bridge Co. is the contractor for the steelwork, and Mr. W. T. Penny is the contractor for erection.

Holding Power of Railroad Spikes.

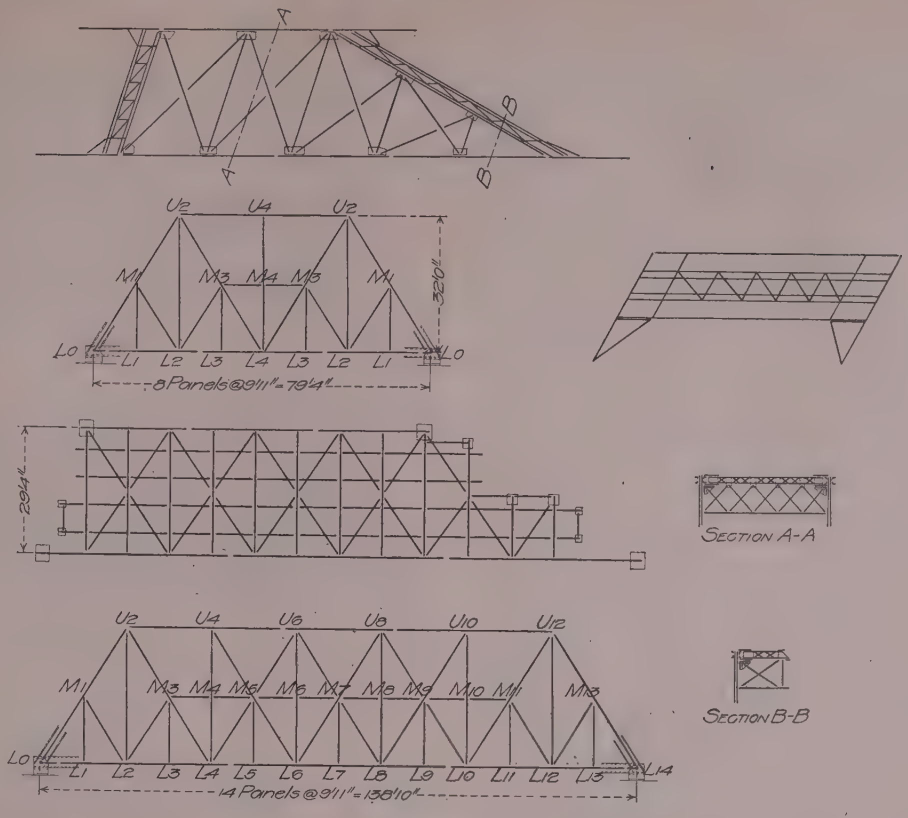
The holding power of railroad spikes in wooden ties has been investigated by the Forest Service of the U. S. Department of Agriculture, and the results of the tests have been made public in a circular prepared by Prof. W. K. Hatt. The purpose of the tests was to determine the relative holding power of common, channeled and screw spikes when driven into both hard and soft wood ties. The ties were in different states of seasoning and some had been treated with preservatives. Spikes of the various forms were driven into each tie. The spikes used were of the following forms: Common spikes, 9/16 in. square and 5½ in. long; channeled spikes, 11/16 in. square over all, and 5½ in. long, with a channel, 17/32x12/32 in., cut in the side away from the rail; common screw spikes, such as those used in the French railroads, 5½ in. long, 15/16 and ⅝ in. in diameter, maximum and minimum, respectively, with a thread of ½-in. pitch, and Illinois Central R. R. screw spikes, which differed from the other screw spikes only in the manner of finishing the thread under the head. The common and channeled spikes were driven to a depth of 5 in. in the usual manner. The screw spikes were screwed down to the same depth in a hole of the same diameter as the spike at the base of the thread. A special steel claw, used with a testing machine, was employed in withdrawing the spikes. In various woods, seasoned and unseasoned, the screw spikes resisted withdrawing with two or three times the force of the common spike, their advantage being more marked in the softer woods. In soaked loblolly pine the channeled spikes showed about 60 per cent. of the holding power of screw spikes and about 12 per cent. more than common spikes. The two forms of screw spikes showed equal values in loblolly pine and the force required to withdraw them was about double that required for plain spikes. Seasoned ties gave a better holding power than those that had been steamed. Common spikes held best in clear wood, but the screw spikes held better in knotty ties. The holding power of a natural tie and one steamed for four hours at 30-lb. pressure was about the same. Steaming for four hours at less than 30-lb. pressure appears to increase the holding power, while steaming for more than four hours at 20 lb. decreases it, according to Prof. Hatt. Ties steamed and creosoted or treated with zinc chloride appear to have less holding power than those simply steamed.

Tests of Sand-Lime Brick made last year at Worcester Polytechnic Institute by Mr. L. N. Reeve showed an average modulus of rupture in cross-breaking of 500 lb. per square inch, and an average compressive strength of 2,160 lb. Freezing and thawing each specimen twenty times had little effect on the modulus of rupture and the compressive strength. Specimens heated to 1,600° Fahr. were decomposed on being plunged at once into cool water. The average absorption of the brick after being immersed for 20 hours was 13.5 per cent.

The Jefferson St. Bridge, Newark, N. J.

Bridge 193, on the Newark & New York Branch of the Central R. R. of New Jersey, is a skew double-track, riveted, through-truss structure, carrying the main line over the intersection of Jefferson and Downing Sts., Newark, N. J., at an oblique angle with both streets. It has been recently built, on the old masonry abutments, to replace an old Phœnix column bridge, which necessitated skewing the new steel work 9 ft. 11 in. in 29 ft. 4 in. on the westerly end, and 49 ft. 7 in. in 29 ft. 4 in. on the easterly end, the skews diverging. The lengths of the north and south trusses are 79 ft. 4 in. and 138 ft. 10 in. respectively, center to center of end pins.

The bridge was designed for the Central Railroad standard loading of two 187.5-ton engines followed by a train load of 5,000 lb. per lineal foot on each track, with allowance for impact and unit stresses, in accordance with the standard specifications of the road. All material is medium open hearth steel. Both trusses are 32 ft. deep and have 19-ft.-10-in. panels sub-divided into 9-ft.-11-in. panels, with the panel points directly opposite so that the floor system is square with the trusses. All connections are riveted except those between the trusses and the main pedestals, which have pin bearings. The panels are subdivided by vertical suspenders from the centers of the main ties, to which the intermediate floorbeams are connected. Horizontal struts were introduced connecting the center points of the intermediate panels in order to give additional rigidity to the truss members.



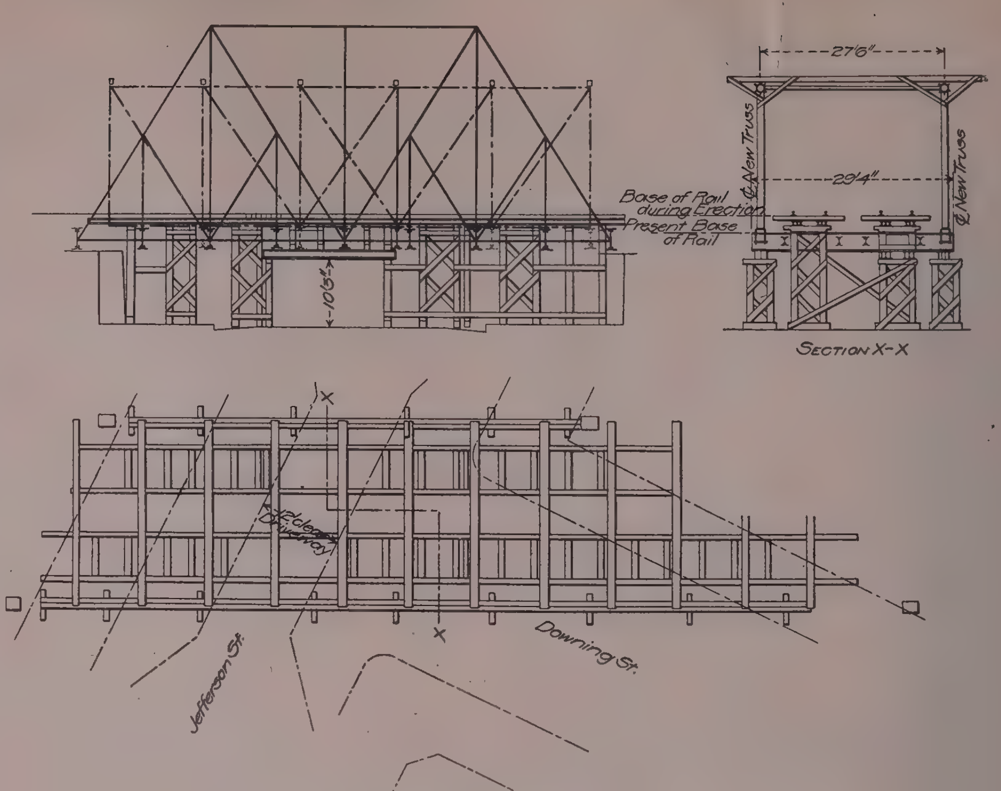
General Diagrams of New Span.

New Truss and Erection Derrick.

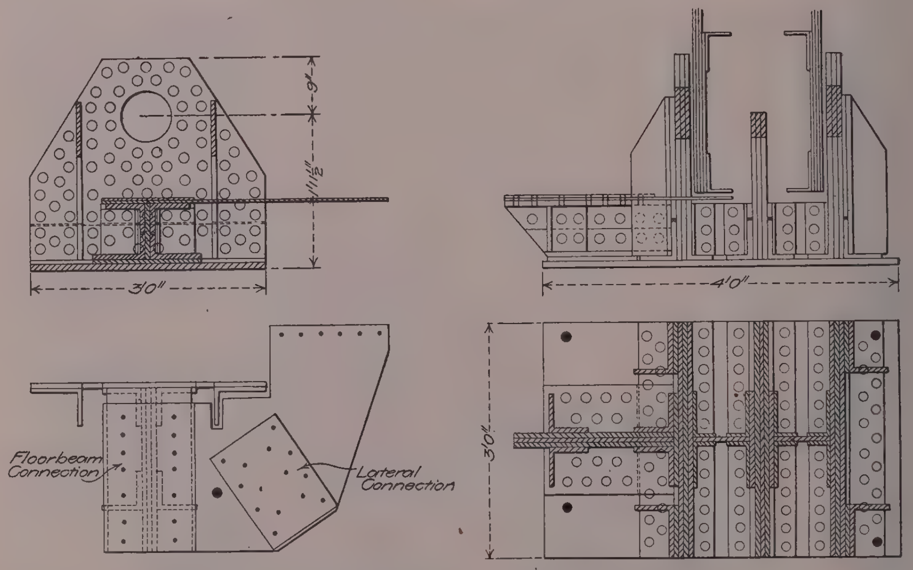
The top chords are made of two 5-in. flats, two 25-in. web plates, and four 6x4-in. angles, with a 28-in. cover plate on top and latticed on bottom. For the short truss the top chord is made in a single section, and for the long truss in three sections, with splices just clearing the gusset and lateral connecting plates. In the long truss, the bottom chord is made with two short end sections each 5 ft. 3¾ in. long and with three intermediate sections, the middle one 49 ft. 7 in. long, and the others each 40 ft. 9¾ in. long. It is made of two 24-in. web plates, two 12-in. plates, and four 6x4-in. angles turned in and latticed top and bottom. Vertical connection plates are shop-riveted to the outside of the web plates to receive the field-riveted connections of the vertical and diagonal members and floorbeams. The webs are stiffened at panel points by transverse vertical diaphragms, and there are ⅜-in. horizontal plates riveted to the bottom flanges to receive the members of the lower lateral system.

The end posts have sections similar to the top chords, and have wide gusset plates at the ends shop-riveted to the posts. The end sections of the bottom chords, 5 ft. 3¾ in. long, were shop-riveted to the end post and to the heavy lower gusset plates. This made heavy members for shipment, but proved very advantageous for erection. All the intermediate posts and sub-verticals have I-shaped cross-sections, and are made of four angles and a web plate. The sub-diagonals are made of two 12-in. channels latticed. The main diagonals have box sections made of four angles and two plates latticed; I-shaped sections made of four angles and a web plate; and I-shaped sections made of four angles latticed, the sections varying as required by the stress sheet. All intermediate posts and diagonals slip in between the main gusset plates shop-riveted and attached to the top and bottom chords, and are field-riveted to them.

On account of the great difference in the lengths of the trusses, the direct connections in the plane of the top chords between the two trusses are virtually restricted to two transverse struts in the center of the bridge and to the portals and diagonals. The main top chord struts are compound members, consisting of an I-shaped upper part and a trussed lower part, together somewhat resembling a lattice girder with a double top flange. For convenience in erection, the upper part was made separate from the lower part. The top lateral diagonals are of the ordinary I-shaped type, made of pairs of flange angles back to back, latticed together and connected by top and bottom flange angle plates at intersections, where one member is made continuous and the other is cut to clear.



Falsework For Old and New Spans and Tracks.



Shoe With Floorbeam and Lateral Connection.

The portals are very long and specially designed to afford maximum rigidity for the span, and to facilitate erection, were built in sections. Each consists in reality of I-shaped top and bottom members connected by diagonal pieces so as to form, like the intermediate struts, a sort of lattice girder. The ends of the top and bottom pieces are connected by heavy solid web-plates, which project beyond the lower side of the portal to form kneebrace brackets in the planes of the inclined end posts, to which they are field-riveted. The top and bottom members of the portals have wide solid web-plates, which project some distance beyond the inner flange angles to provide for the field-riveted connections of the diagonals.

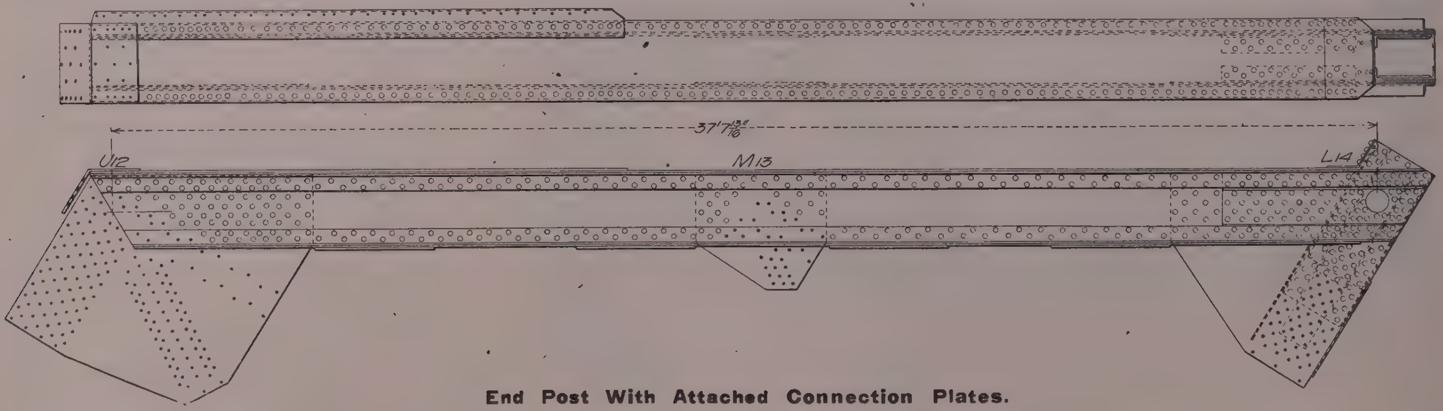
The bottom lateral system consists of single heavy X-brace angles field-riveted to the bottom chord lateral connection plates and to horizontal plates on the lower flanges of the floorbeams, which the diagonals are cut to clear.

The 37-in. intermediate floorbeams are of ordinary construction, with the web made in one long center section and two short end sections, which project above the top flanges to form knee-braces and extend the field-riveted connections to the vertical posts. At the east end of the bridge the long truss projects more than three panels beyond the end of the short truss and the floorbeams at these points are connected at one end to the long truss and at the other end are seated on the masonry. At the west end the long truss extends one panel beyond the short truss. The floorbeams at each end of the short truss are seated on special pedestals made integral with the shoes and provided with horizontal connection plates to receive the bottom lateral diagonals. The floorbeams are secured to the pedestals by four 1¾-in. anchor bolts.

Previous to the erection the old top lateral system was replaced with 10x10-in. transverse timbers 38 ft. long, clamped across the top chords at panel points and stiffened with double 3x10-in. knee-braces at each end. The panels between these struts were X-braced with 3x10-in. planks just above the planes of the top chords, and the old portals, knee-braces, lateral struts and diagonals were removed, excepting the upper angles of the portals, so as to give clearance for traffic on the tracks, which were then successively jacked up 2 ft. between trains and blocked up with three lines of 8-in., 18-lb. I-beams under each rail on the old iron floor system, the I-beams being supported about every 5 ft. The approaches to the bridge were temporarily raised at the same time with grades not exceeding 2 per cent.

Two center lines of trestle bents were then erected under the tracks, and the I-beams supporting the tracks were wedged up on these bents, thus releasing the old floor system and throwing the original structure entirely out of service. Two outer lines of falsework bents were then erected under the old trusses and the ends of the old floorbeams, and wedged up to carry them at panel points. The old trusses, stringers and floorbeams were then removed, and the new floorbeams, stringers and trusses erected in the order named, the new work being carried on the outer line of falsework bents. After the trusses were completed and swung, the tracks were lowered between trains to their final position on the new floor system.

The temporary falsework supporting the tracks was composed of two lines of timber bents X-braced by transverse diagonal planks and longitudinal and diagonal bracing, forming successive towers and open panels, arranged for convenience in removing the old stringers and floorbeams and placing the new floor system.



End Post With Attached Connection Plates.

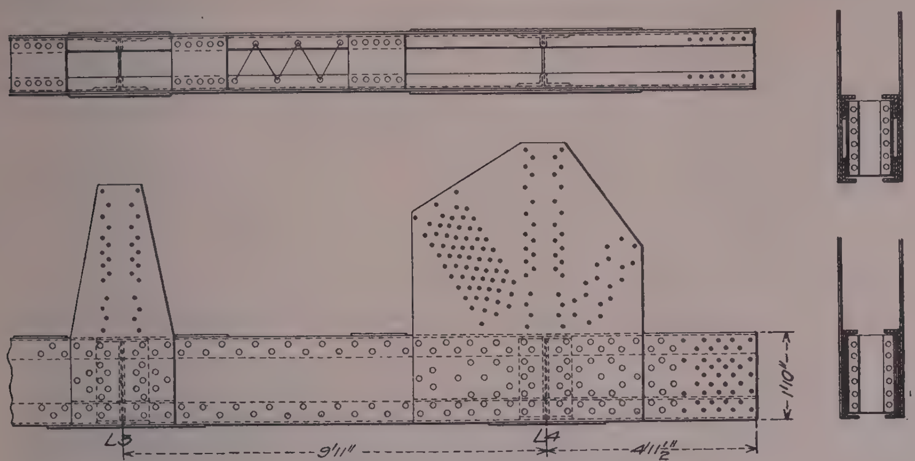
The falsework did not allow clearance for traffic on Downing St., but a passage about 12 ft. wide and 10 ft. 3 in. high in the clear was provided on the center line of Jefferson St. by spacing the bents to correspond and supporting two sets of 15-in. I-beams on them to carry two intermediate pony bents supporting both the tracks and the old trusses.

The old floorbeams and trusses were temporarily supported by four lines of 6x16-in. stringers carried on X-braced tower bents with the exception that six lines were used over the temporary driveway. Speed was reduced to four miles per hour and railroad traffic was maintained on both tracks except on one day from 6 A. M. to 5 P. M., when the tracks were raised to the temporary position; three days from 10 A. M. to 4 P. M., to allow clearance for riveting scaffolds on the inside of the trusses; and on two days from 10 A. M. to 4:30 P. M., when the tracks were lowered to their final position, traffic having been maintained on one track during these hours.

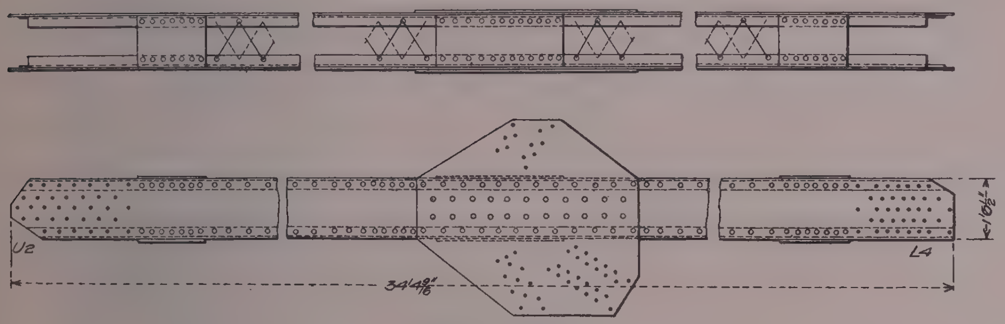
All field rivets were driven by air, the compressor being located at the east end of the span. The new steelwork weighs 546,000 lb. and was erected with an average force of 25 men in 100 days. The old span was taken down and the new span erected by means of two 30-h.-p. hoisting engines, each with two drums and four spools, located at the east end of the span, and two derricks set up in the streets, one on each side of the span near the centers of the trusses. The derrick on the north side had an 80-ft. wooden mast with a 60-ft. steel boom, and the derrick on the south side a 90-ft. steel mast with an 80-ft. steel boom. The two booms commanded the whole span.

The shop work was carefully executed and the members were assembled without any trouble in the field.

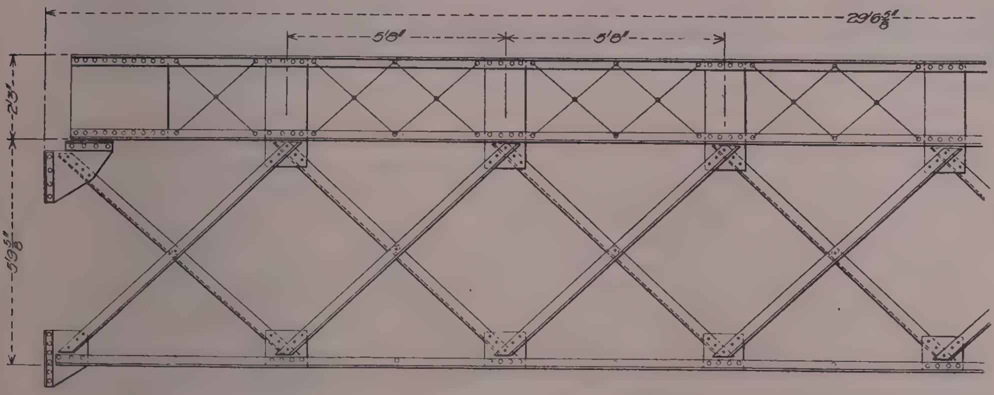
The work was designed and constructed under the direction of the Engineering Department of the Central Railroad of New Jersey, Mr. Joseph O. Osgood, chief engineer. The special features of the design and the details and methods of erection were worked out by Mr. Austin Lord Bowman, bridge engineer. The superstructure was fabricated and erected by Lewis F. Shoemaker & Co., Philadelphia, Pa., Mr. J. H. Fichthorne, chief engineer, and Mr. L. D. Rights, contracting manager, who had special charge of the erection.



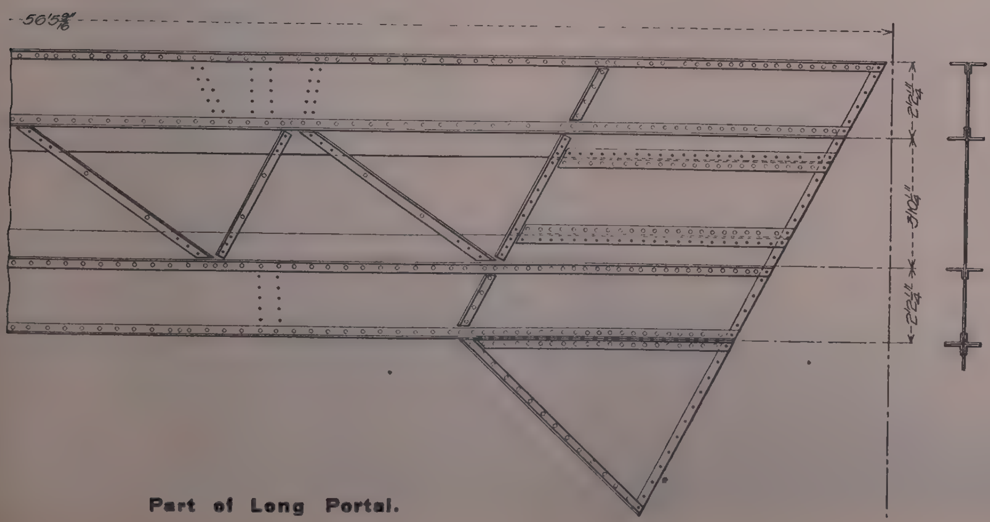
Bottom Chord Section.



Inclined Post.



Upper Transverse Strut.



Part of Long Portal.

The Tehuantepec Railway.

The Tehuantepec Railway across the isthmus of the same name in southern Mexico has been opened to traffic. The road, which is 190 miles long, is designed to transfer the cargoes of vessels from one ocean to the other, and is expected to be a competitor of the transcontinental railroads of the United States. The terminus on the Pacific Ocean is Salina Cruz; and on the other side of the isthmus, Coatzacoalcos, on the Gulf of Campeche. At both of these ports extensive works have been constructed for facilitating the speedy and safe transfer of cargoes. The highest point reached by the road is at Chivela Pass, 855 ft. above sea level. At this point the construction work was particularly heavy, there being two horseshoe curves and one tunnel, a maximum gradient of 2.07 per cent. being used and a maximum curvature of 21.8 deg. For the remainder of the line the maximum curvature does not exceed 11.6 deg., and the maximum gradient, 1.6 per cent. The bridges are numerous and of steel construction, plate girders, and lattice girders of the Pratt type, being mostly used. The longest bridge measures 660 ft., made up of seven spans. Standard gauge is used. The ties are creosoted pine, native hardwood or California redwood, laid with 80-lb. rail. The track is a single one, but a double track is to be constructed and has been arranged for. The bulk of the rolling stock has been built in the United States. The locomotives are of the new oil-burning type. The steamers of the American-Hawaiian Steamship Co., which have heretofore been running from New York to San Francisco and Hawaii via the Straits of Magellan have discontinued that service, and now run to Santa Cruz, their cargoes being transferred to the Atlantic side by the new railroad.

TEN MULTI-STAGE CENTRIFUGAL PUMPS driven by 800-h.-p. induction motors will be furnished by the Allis-Chalmers Co. for the New York fire protection system.

Granite-Top Macadam in Oak Park.

A paper read before the Illinois Society of Engineers and Surveyors by R. A. Carpenter.

Up to the year of 1899, Oak Park had been striving to get a street pavement which would fill the conditions for a residence suburban town as to cost, general appearance and durability. Prior to the above date pavements had been constructed of limestone macadam, cedar block in the business district (which has since been displaced by brick), and two streets of asphalt. The curbing used in a majority of the above pavements consisted of limestone in 6 ft. lengths, 30 in. in depth, hammer-dressed to 12 in. on the face and 6 in. on the back, and to a thickness of 4 to 6 in.

The difficulties arising from the pavements existing at that time was mainly this: The limestone macadam streets were constructed with insufficient crown, and ground up rapidly under the action of traffic and were exceedingly dusty if not properly sprinkled. Cedar block pavement was expensive at almost any cost, and especially so at $1.00 per yard when the life of the pavement did not exceed seven years and the abutting property was compelled to stand a second assessment to replace the old cedar block. It may be well to state at this point that at that time the Board of Local Improvements of Oak Park refused to consider any petition from property owners for paving with cedar blocks. Asphalt pavement, while desired by a few residents, did not meet with general approval from the fact of its being too expensive and a possibility in a very few years of being badly cracked up, this giving the street a very untidy appearance and also lessening the life of the pavement.

Under the conditions as herein briefly set forth, the first ordinance was drafted for paving Euclid Ave. a distance of 2,200 feet, with a granite-top macadam pavement. The roadway on this avenue was paved to a width of 30 ft. between face of curb and included the gutter flags, which were combined with the curb.

The curb and gutter was constructed on a bed of cinders 8 in. in thickness. The curb was 7 in. in thickness with an average height of 12 in., and combined with a gutter flag 18 in. wide and 6 in. thick. The curb exposed at the summits of the gutter was 4 in., and 8 in. at the outlets of the gutters. The combined curb and gutter was constructed from Portland cement, fine granite screenings and crushed granite in proportions of one part of cement, two parts of granite screenings and four parts of crushed granite. One inch on top of gutter flag and roadway face of curb was composed of one part of cement and one part of fine granite screenings. The curb and gutter was laid in 6-ft. sections, and the corners at street intersections were rounded to a radius of 6 ft. and at all public alleys rounded to a radius of 1½ ft.

The roadway between the gutter flags was excavated to such a depth and in such a manner that after the subgrade had been thoroughly rolled with a steam roller of not less than ten tons weight, and after the different courses of material had been placed thereon, the finished pavement in the center of the roadway would be 6 in. above the top of the curb giving an average crown of 1 ft. in 30 ft.

On the sub-grade the first course was composed of macadam limestone bonded with limestone screenings, and measured 8 in. in depth over the entire roadway between gutter flags after rolling. On top of the 8-in. course of macadam was placed a layer of medium limestone bonded with limestone screenings, measuring not less than 4 in. in depth over the entire roadway after rolling.

On top of the 4-in. limestone course was placed a layer of medium crushed granite on top of which was placed sufficient bonding gravel to thoroughly fill all interstices, and as the rolling was in progress the roadway was thoroughly drenched with water and the rolling continued until all water placed upon the pavement would seek the gutter, indicating a thoroughly bonded pavement. The course of granite measured not less than 3 in. over the entire pavement after rolling.

On top of the bonded granite course was placed a layer of pea granite ½ in. in thickness over the entire roadway and the whole roadway thoroughly rolled, compressing, so far as possible the pea granite into the bonding gravel. The gutters were then thoroughly cleaned by brooms and the entire street barricaded for one week to thoroughly dry out and harden. At the expiration of one week the avenue was thrown open to traffic, and for seven years has required no maintenance further than cleaning and sprinkling, and has always been perfectly satisfactory to the abutting property owners who paid for the improvement.

At the time the Euclid Ave. paving was completed, there were many residence streets in Oak Park ready for improvement. A large majority of the petitions received by the Board of Improvements for paving streets in Oak Park since that time have been for granite top macadam with a request that the specifications be the same as Euclid Ave. Many streets up to the present have been paved in this manner, approximating $250,000, including those constructed by special assessment and private contracts.

Experience has shown there are a number of points to be observed in constructing granite-top macadam pavements in order to give the best results.

First, it is advisable, where it can be done, to make a system out of each special assessment and pave all streets both ways within the district comprising the system, and thus avoid so far as possible the mud from unimproved streets being deposited on the pavement. A single paved macadam street extending into a district where all the cross streets are unimproved will be injured more from the mud of the cross streets being deposited on the paved streets than from all the traffic on the street in ordinary dry weather. It will further be found where a single street is paved in an unimproved district, traffic (both heavy and light) will in nearly all instances go considerably out of the way in order to take advantage of a paved street, which is unfair to the owners of abutting property who have paid for the improvement.

Second, one of the very important questions in constructing granite-top macadam streets is to give plenty of crown, 12 in. on a 30-ft. roadway is none too much, and also to be sure that the rolling is continued long enough on the granite course to insure the street being thoroughly bonded.

Third, one of the mistakes that is often made in constructing streets of this character is in using too much bonding gravel. A great deal of care should be exercised in spreading the gravel (and especially so when the gravel is wet and chunky), otherwise it will be found patches will appear where the gravel is greatly in excess and other places where there is an insufficient amount to receive a bond. Any overplus of gravel on a street when opened for traffic will cause the pavement to mud up badly during wet weather, and dust in dry weather. The least amount of gravel that can be used and still have all interstices filled will give the best results, and cause the least trouble on maintenance in the future.

The average estimated cost per square yard on granite top pavements in Oak Park is $1.35, and granite curb and gutter 70 cents per lineal foot.

Improvements to the Water Works System of Waupaca, Wis.

The city of Waupaca is in the central portion of Wisconsin, on the southern edge of a very large granite outcrop. A short distance south of this locality is found the northern limit of the Potsdam sandstone which is the source of many artesian wells in Illinois as well as Wisconsin. For a number of years Waupaca has been supplied with water from the Waupaca River, which flows through the city. This water was pumped by power developed on the same river at the pumping station of the water works.

The river water was very turbid at times and was scarcely fit for domestic use a portion of the year. Besides this objection, the water was extremely cold in winter, so that the distribution mains froze up very quickly where there was little or no circulation. During the cold winter of 1903-04 the mains were frozen to such an extent that it cost the city nearly $8,000 to make the repairs the following spring. The problems to be solved were to secure a new source of supply that would be suitable for potable purposes, and one of higher temperature in winter so that the mains would not freeze.

As there was considerable objection made to the proposed improvements, the council passed a resolution to the effect that if the improvements would cost over $14,000, in addition to materials and funds on hand, the bonds voted for the purpose would not be issued, and the work would not be done. During the summer of 1904 Mr. W. G. Kirchoffer conducted an investigation of the conditions at Waupaca, and after making several test borings found there was an extensive sheet of underground water flowing in the sand above the granite rock in a general southeasterly direction. The development of this ground water was the subject of a paper by Mr. Kirchoffer presented at the recent convention of the Illinois Society of Engineers and Surveyors.

Mirror Lake, a body of water near the city, as well as many other lakes about Waupaca, lie in a depression below this general water table. This fact was very apparent along the west bank of this lake, where it was proposed to develop the supply. The whole western bank of the lake was almost one continuous spring, the sand at this locality having an effective size of 0.22 m.m. The temperature of this ground water was found to be 48° Fahr., which was much higher than that of any of the other lakes or of the river.

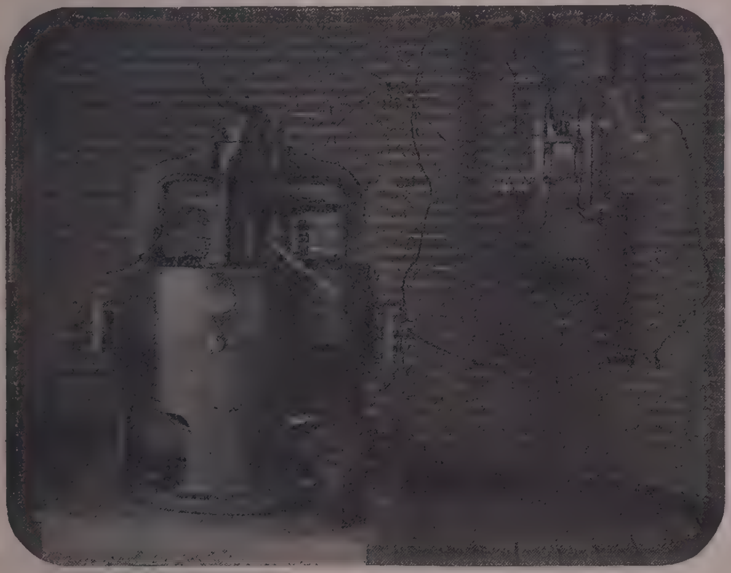
The decision was made to develop this ground water supply by driving a number of tubular wells on the bank of Mirror Lake. In order to keep the cost of the improvements as low as possible a hydraulically-operated electric generator was installed at the old pumping station and the electrical power transmitted to a new pumping station adjacent to the wells. At the chosen locality, thirteen 5-in. tubular wells, with points 3½ in. in diameter by 10 ft. long, were put down to a depth of 25 to 40 ft., depending on the coarseness of the material penetrated. The points were covered with No. 60 wire gauge and No. 3 sheet brass. The wells were spaced 10 ft. apart and were connected to a horizontal suction pipe 6 and 8 in. in diameter. This pipe was laid about 3 ft. below the surface of the ground and 1 ft. below water level to prevent possible air leaks in the suction pipe.

The pumping station is a round building, 18 ft. in diameter, built over a pump well 8 ft. deep. The construction of this pit in the loose sand and the flowing water was carried on with difficulty on account of the limited amount of machinery and apparatus available. After the contractor had failed several times in his attempts to pump out the water and sand and to sink the brick wall, Mr. Kirchoffer took charge of the

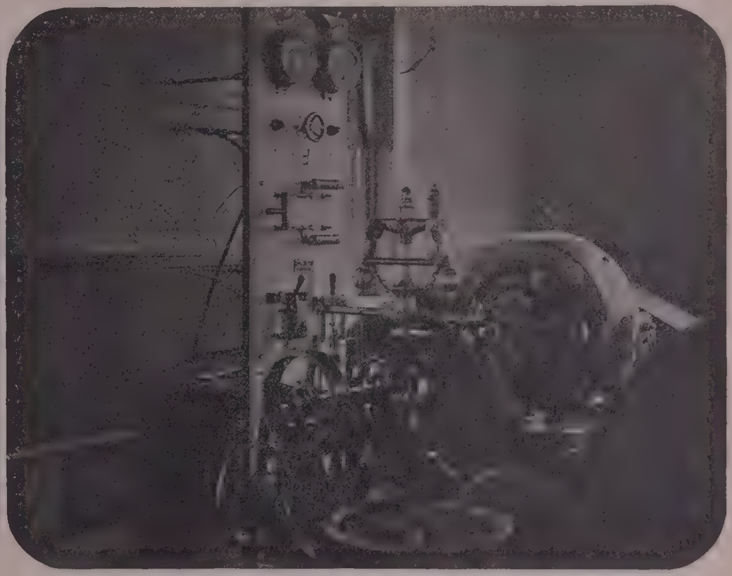
TABLE 1.—TEST OF A THREE-STAGE, 700-GAL., HIGH-LIFT CENTRIFUGAL PUMP AT WAUPACA, WIS.

Head pumped against, ft.	Vacuum, ft. of water.	Total head, ft.	Speed, r.p.m.	Voltage at power station.	Amperes.	Gallons per minute.	E.H.P. at power station.	E.H.P. delivered at motor.	W.H.P. of pump.	Efficiency of pump & motor.	Efficiency of pump, motor eff., 85%.
150	19¾	169¾	880	550	116	1080	85.40	76.86	45.80	59.50	70.00
160	19	179	875	550	110	1016	81.10	72.99	45.40	62.30	73.40
170	18	188	876	550	107	985	78.90	71.01	46.20	65.10	76.70
180	17	197	878	550	104	927	76.60	68.94	45.60	66.20	77.90
185	16⅛	201⅛	878	550	102	867	75.20	67.68	43.50	64.30	75.80
190	15½	205½	873	550	102	840	75.20	67.68	43.20	63.80	75.20
195	14⅞	209⅞	873	550	102	813	75.20	67.68	42.60	63.00	74.25
200	14⅛	214⅛	870	550	102	784	75.25	67.73	41.90	61.80	72.80
190	15⅛	205⅛	869	550	102	826	75.25	67.73	42.30	62.60	73.70
180	14¼	194¼	830	500	100	813	67.20	60.48	39.50	65.25	76.80
190	16½	206½	882	550	110	867	81.10	72.99	44.70	61.20	72.00
180	17¼	197¼	876	550	109	927	80.30	72.27	45.67	63.20	73.40
160	18	178	856	530	108	985	76.70	69.03	43.80	63.50	74.80
185	16⅝	201⅝	869	530	108	867	76.70	69.03	43.70	63.25	74.40
185	16	201	872	530	108	867	76.70	69.03	43.50	63.00	74.25
185	9¼	194¼	798	420	95	552	53.50	48.15	26.80	55.70	65.70
176	10¼	186¼	772	415	97	565	53.80	48.15	26.30	54.60	64.30
176	10½	186½	786	415	97	575	53.80	48.15	26.80	55.70	65.70

work and succeeded in sinking the wall of the pit by driving two of the large well points in the bottom of the excavation and removing the water without disturbing the sand.



Substation Motor Temporarily Wired.



Governor, Generator and Switchboard.

The wall was lowered to the proper depth by removing the sand with shovels and while the pit was thus practically dry, the concrete bottom was put in place. This was not entirely successful as the pit leaked considerably after the concrete had set, but the water could easily be kept out with a siphon operated by water from the city mains. After the new motor-driven pump was installed it was attached to one of the well points which was left in the center of the pit and the water was thus kept down while another layer of concrete was put in place, which second layer effectually stopped the leaks.

On account of the fact that the pump well was likely to be flooded from a rise in the level of the lake and on account of its adaptability for a motor-drive, a high-lift Byron Jackson centrifugal pump of the vertical type was adopted. This pump has a capacity of 700 gal. per minute against a head of 200 ft., when running at a speed of 850 r.p.m., and is driven by a 75-h.-p, direct-current vertical Northern motor.

At the old pumping station a 75-kw, 500-volt Northern generator was installed and belted to the jack shaft of the two 75-h.-p. water wheels. The switchboard was so arranged that the pump could be started from this station, and so that in cases of emergency the pump could be operated from the current supplying the street railway which is operated by the local electric lighting company. The municipal plant could in return operate the street cars if necessary.

The transmission line from the power house to the sub-station consisted of two No. 0000 wires and one No. 10 starting wire. The same poles carry the wire for a private telephone line between the two stations so that during the time of construction and making the tests, communication could be had with the operator at the power house. The motor is controlled from the power house so it is only necessary for the operator to visit the sub-station once a day to see that all of the bearings are properly oiled.

After the pump and motor were installed and in successful operation, a test was made upon the plant to determine its efficiency and capacity. The results of this test are shown in Table 1. The efficiencies obtained for the pump may be seen from the table, the guaranteed efficiency being 59 per cent.

All of the work done on this plant except the construction of the power house was done under the supervision of Mr. C. H. Phillips, who was then superintendent of the plant. The low costs of doing the work, which are given below, were largely due to Mr. Phillips' skillful management, Mr. Kirchoffer said, and to the fact that the excavation of the trenches was all in white sand, except one block in granite rock on Elm St. The costs of the improvements was as follows., common laborers receiving $1.50 a day, as a rule:

Cast Iron Pipe: 3,120 ft. of 4 in., $1,053,62; 1,608 ft. of 10 in., $1,188; 3,000 lb. specials, $90; total, $2,331.62.

Valves and Hydrants—Eight hydrants, $215; one 10-in. gate valve, $26.50 one 5-in. gate valve, $12; three valve boxes, $14.75; total, $268.25.

Lead for whole work, $198.33; gas pipe and sundries, $178.30.

Laying Pipe—Royalton St., 7 ft. trench, 875 ft. of 6-in., 1,237 ft. of 4-in., 742 ft. of 1-in., 1¼-in and 1½-in., or a total of 2,854 ft. at 13⅞ cts. a foot, $393.92. *Berlin St.*—7 ft. trench, 935 ft. of 4-in. at 18 cents a foot, $168.89. *North St.*.—7-ft. trench, 432 ft. of 4-in. at 18¼ cts. a foot, $79.35. *Main St.*, 196 ft. of 12-in., 1,095 ft. of 10-in., and removal of 716 ft. of 6-in., and setting two hydrants, total 1,291 ft. at 22⅓ cts. a foot, $288.21. *Elm St.*, 862 ft. of 4-in. in earth at 22.8 cts. a foot, $196.26; 300 ft. of 4-in. relaid in granite rock at $1.1873 per foot, $356.20; total for Elm St., 552.46, and a grand total for pipe laying of $1,482.83.

Transmission Line.—53 poles and cross arms, $126.88; peeling poles and setting same, $55.09; putting up wire and cross arms, $56.98; foreman, $13.50; paint and painting two coats, labor, $38.38; 10,600 ft. of No. 0000, 5,300 ft. of No. 10 wire at 17⅕ cts. per pound, $1,452.10; 6 lightning arresters, $14.58; supplies, freight, etc., $10.83; total, $1,768.34.

Power Plant.—75-kw. generator and switchboard, $980; waterwheel governor, $450; shaft extension, pulley and belt, etc., $181.36; lumber, cement and sundries, $55.14; cost of installing, $50.82; pump and motor, $1,600; choke coils, switch, etc., $33.88; installing, $57; total, $2,408.20.

Power house, 18-ft. diameter and 8-ft. pit, $843; completing floor and sundries, $48; total, $891.

Wells.—Points, piping, etc., $837.53; coal for engine, $27.56; hardware and small fittings, $69.12; lumber for sheeting, $22.05; labor, drilling and connecting up wells, $515.07; sundries, $12.25; total, $1,483.58.

Miscellaneous.—Telephone line, $25; land, $1,528; engineering and incidental expenses, $700; making a grand total for the improvements of $14,663.45.

THE STEAM TURBINE POLICY of the Bureau of Steam Engineering of the U. S. Navy Department, as explained in its last annual report, is very conservative. The Bureau has preferred to wait before adopting it extensively until it had been demonstrated as unquestionably the best system of propulsion for naval purposes. At the same time tests and inspections have been made when opportunity offered and extensive investigations of the question have been carried on. It is believed that when the three scout cruisers now building (two with turbines and one with reciprocating engines) are completed and their trials have been held, comparative data of the utmost value will be obtained. A 50-ft. launch, to be fitted with turbines, is building at the Portsmouth Navy Yard for comparison with boats of the same size fitted with reciprocating engines.

Heating and Ventilating Plant of the United Engineering Building, New York.

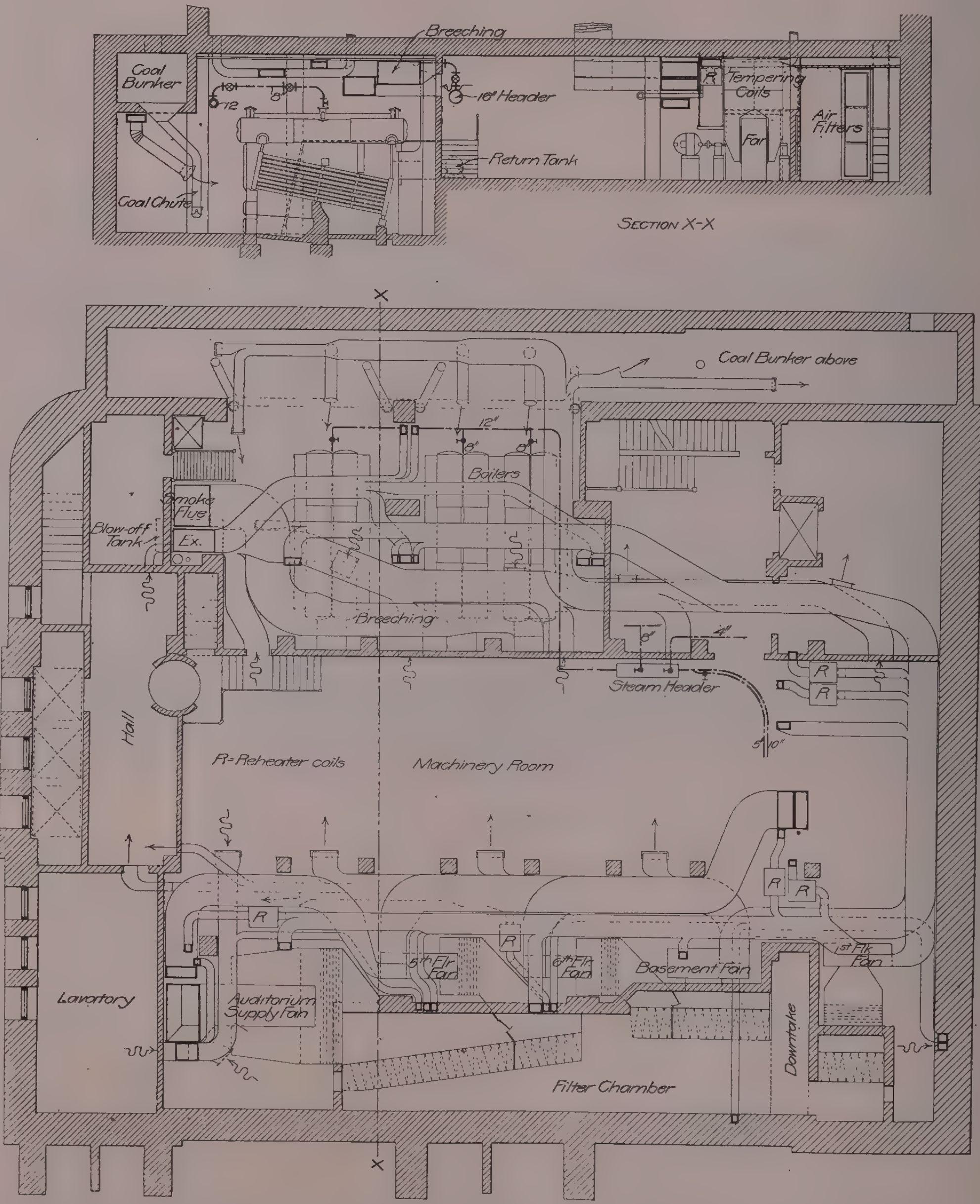
The new United Engineering Building in New York, which has been recently occupied by the American Institute of Electrical Engineers, the American Society of Mechanical Engineers and the American Institute of Mining Engineers, has an unusually complete mechanical plant. The building is a fourteen-story steel-cage structure having a frontage of 125 ft. on 39th St., between Fifth and Sixth Aves., and a depth of 100 ft. In accordance with the building laws, it covers but 85 per cent. of the area of the site, an open space having been left on all sides of the building for lighting and ventilation purposes. The handsome entrance hall and reception rooms are on the main floor, an auditorium occupies the greater part of the third and fourth floors, there are assembly rooms and lecture halls on the fifth and sixth floors, the office accommodations for the various societies are on the seventh to twelfth floors inclusive, and the engineering library on the thirteenth and fourteenth floors. Further particulars concerning the building and plans of the principal floors were published in The Engineering Record of Dec. 16, 1905.

Its mechanical features are interesting and complete. Ventilation, both supply and exhaust, have been provided for all rooms for public functions. Fresh filtered air is supplied to these rooms and distributed in a most complete manner, the fresh air introduced being automatically tempered and moistened according to requirements. The ventilating plant provides for very generous change of air in the main auditorium, as well as in all promenades in connection with it where smoking is permitted. All toilet rooms in the building have been provided with exhaust ventilation, the replacing air being admitted through louvres in the door panels, thus preventing the escape of odor to the corridors. The entire building is heated by direct radiation except the main entrance hall on the ground floor, where the architectural treatment of the interior did not permit proper locations for the necessary direct radiation and indirect heating became necessary. All the heating, including the tempering and air moistening, and heating of hot water for the plumbing supply, is effected by low-pressure steam. The direct radiation, as well as the tempering and heating coils and moistening apparatus, is under automatic temperature control throughout all portions of the building.

Except for a few coils in skylights, radiators of the Peerless type are used everywhere, located for the greater part below the windows, so as to counteract the direct glass exposure, the down draft and any possible in-draft from the windows. They are generally exposed in the rooms, but in the front assembly room on the fifth floor they are set in floor pockets, so as to give access to the balconies located outside the windows. These radiators are encased in copper boxes connected with intake and outlet registers for air circulation.

Of the total basement area of 94 x 108 ft., including the space under the east and rear driveways, a 38x60-ft. space at the rear is devoted to the boilers, while the remaining space, 55 x 92 ft. in size, is a machinery and fan room, with a visitors' gallery at one end. At the rear a 6x9-ft. enclosure extends through the upper part of the boiler-room, providing for coal storage. There is a clear headroom of 15 ft. in all portions of the basement except the boiler-room, the floor of which is depressed for a clear headroom of 21½ ft.

There are three Babcock & Wilcox water-tube boilers of the wrought-steel header type, having an aggregate heating surface of 5,226 sq. ft. and an aggregate grate surface of 129.6 sq. ft. Each boiler has ten tube sections, two drums 36 in. in diameter and 20 ft. long, and one wrought-steel mud-drum, 7¼ in. square. Each section is composed of nine 4-in. tubes 16 ft. long, expanded into forged steel headers of serpentine form. The boilers and their fixtures and piping are designed for high pressure, so that steam for operating a possible future power plant can be furnished should the management of the building ever desire to install its own electric plant. The boiler plant is at the present time operated at low-pressure inasmuch as it is only required for heating and for tempering and moistening the air supply.



Arrangement of the Mechanical Equipment in the Basement of the United Engineering Building.

The boilers are arranged for hand firing and are fitted with Treadkill grates, designed to burn anthracite coal. The coal is drawn through chutes from an overhead bunker having a total capacity of about 200 tons. This bunker is built of steel and concrete and is suspended over the firing-room and directly under the rear driveway, so as to be filled by dumping directly from wagons. The ashes are removed in cans and raised to the driveway by means of an ash-lift at the rear of the building.

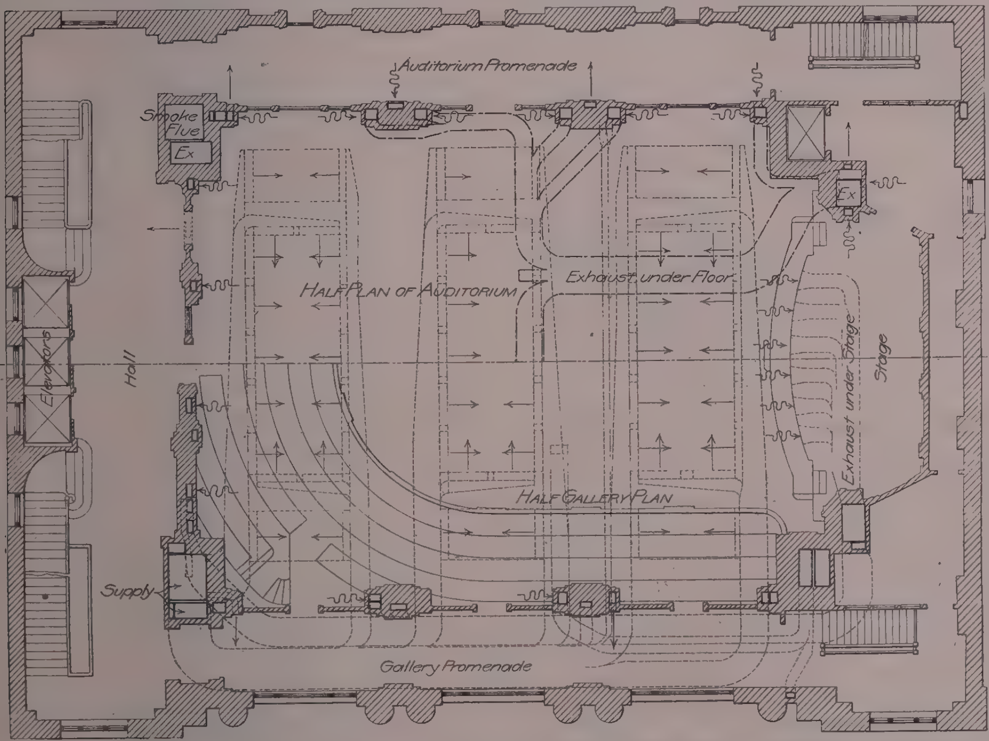
The chimney is a steel stack, 4 ft. square and about 200 ft. high, carried up to a point above the roof, in a shaft together with exhaust ducts and exhaust and vapor pipes. In order to minimize the heat transmission, it is covered with magnesia blocks 1 in. thick, applied so as to form an air space between the iron and covering, and the brick enclosure surrounding the smoke-stack and the various pipes has also been insulated by 1½-in. magnesia blocks applied on the brickwork. The breaching connecting the boilers with the stack is No. 8 gauge steel plate, braced with angle and T-irons, and is covered with 1½-in. magnesia in the same manner as the stack. A swinging damper controlled by a Locke automatic damper regulator is provided in the main smoke connection at its entrance to the vertical stack.

The condensation from the heating system, from the tempering and moistening apparatus for the air supply, and from the hot-water tanks, is returned to the boilers by gravity. The various returns are connected into a horizontal return tank, 2 ft. in diameter by 8 ft. long, which is so arranged that it can readily be converted into a pumping return tank if, at a later date, a power plant be installed and the boilers be operated at high pressure, making the pumping of the returns to the boilers necessary. The fresh water supply from the city mains to each boiler for make-up is controlled by an automatic feed regulator, which automatically maintains the water level in the boilers and makes up any loss by condensation.

The boilers have 2½-in. blow-off connections from the mud-drums, which are connected into one main blow-off line, leading to a blow-off tank 3½ ft. in diameter by 7 ft. long, located in the pumproom at the west side of the boiler-room.

The discharge from the blow-off tank is raised from this tank to the sewer by a Worthington single-stage turbine pump, designed specially for handling of hot water, which is driven at 1,000 r.p.m. by a direct-connected 4-h.-p. motor. The blow-off tank is fitted with a cooling coil for lowering the temperature of the blow-off discharge before entering the sewer; this coil consists of 50 lin. ft. of 3-in. brass pipe, through which is circulated the fresh water supply leading to the hot water heater of the plumbing system. The blow-off tank has a 5-in. vapor pipe, which is carried up to the roof through the smoke flue enclosure and terminated with a condenser head.

The steam connections from the boilers are connected into a 12-in. steam header in the boiler-room, which header in turn connects with a 16-in. distributing header in the machinery room, all arranged in such a manner as to simplify the pipe connections if, at a later date, an electric generating plant is installed. All piping and fittings, liable to become power piping at a future date, are designed for high pressure. The 12-in. steam header in the boiler-room is suspended over the firing-room floor, and is connected with the steam nozzles on the boilers by 8-in. double-valved branches. Four mains are extended from the distributing header, and are connected with their respective systems, and corresponding returns are carried to and connected with the return header. The main for the direct radiation is 8 in. in diameter, and divides into a 6-in. and a 7-in. branch. A 10-in. main supplies steam to the tempering coils and the main for the moistening apparatus is a 5-in. line. The fourth branch is a 4-in. main which supplies steam to the hot-water tank of the plumbing system.



Scheme of Ventilation Connections to the Auditorium, Showing Location of Ceiling Supply Outlets.

There are sixteen riser lines supplying steam to the direct radiation on the upper floors, exclusive of a number of radiators on the first floor, which are supplied from the ceiling mains in the basement, with short branch connections through the floor. The steam risers vary in size from 2½- to 3½ in. diameter. All rising lines are anchored at the fourth floor and the tenth floor levels, and have expansion loops in the seventh story floor construction. All rising lines, as well as all branches from the risers to the radiators, are concealed, and the radiator branches are run in trenches below the finished floor. The expansion loops are run in floor pockets, and the radiator branches and the expansion loops are covered with magnesia sectional covering, and further protected by No. 24 gauge galvanized iron. The pockets for the expansion loops are made water-tight and filled with loose asbestos, packed around the non-conducting covering of the loops.

The sizes of steam and return connections for the radiators are as follows: 1-in. steam supply and 1-in. return for radiators having 36 sq. ft. or less; 1¼-in. supply and 1-in. return for radiators up to 72 sq. ft.; 1½-in. supply and 1¼-in. return for radiators up to 120 sq. ft.; 2-in. supply and 1½-in. return for radiators up to 280 sq. ft. The steam supply risers and steam supply mains and branches are all dripped into the return mains, the drip connections having a minimum size of 1 in.

The return system consists of groups of return mains corresponding with the supply mains, and connecting with the return tank in the engine-room. The return from the direct heating is a 4-in. main; the return from the tempering coil is 5 in. in diameter, the return from the moistening pans is a 3-in. line, and the return from the hot-water tanks is a 3-in. line. All individual return branches are carried down to a point below water level, so as to seal them, and check valves are installed in all return connections from the tempering coils, evaporating coils and sky light coils, which open toward the boilers, but prevent return water of condensation from being sucked into the coils. All steam, return and other pipes and fittings in connection with the heating and ventilating work are covered with 85 per cent. magnesia sectional covering, which is encased in 10-oz. canvas sewed on and painted.

The ventilating equipment of the building provides for fresh air supply for the basement and first to sixth floors inclusive by means of five centrifugal fans in the basement, and exhaust ventilation for all rooms on these floors and for the toilets by means of four disc fans in houses on the roof. The fresh air supply systems are fitted with tempering coils for raising the temperature of the air to that of the rooms supplied, provisions for temperature regulation consisting of outside thermostats located in the cold air intake and thermostats in the ducts connecting with the various systems. The humidity of the air delivered is adjusted automatically by air moisteners of the steam-heated evaporating pan type under humidostat control. For the basement, fresh air is used, without preheating, thus serving to lower the temperature of the heated machinery sections, as well as for ventilating.

The fresh air fan equipment consists of a 5-ft. blower for the air to the first floor and entrance hall, a 9-ft. blower serving the auditorium section, which embraces the second, third and fourth floors, a 5½-ft. blower for the assembly rooms on the fifth floor, a 5-ft. blower for the lecture rooms on the sixth floor and a 6-ft. blower for the unheated fresh air to the boiler and machinery rooms. The fans are all of the full-housed upward discharge Sturtevant type, and are motor driven, the capacities, speeds and sizes of motors being indicated in the accompanying table. They are driven by C. & C. field-controlled slow-speed, direct-current electric motors, direct-connected to the fan shafts through flexible flange couplings. They are fitted for variable-speed operation, having a range of from two-thirds to full speed in six steps by field control.

FAN EQUIPMENT IN UNITED ENGINEERING BUILDING.

Floor.	Capacity.	Size.	Speed.	Motor.
Supply.				
First	10,000 cu. ft.	5x2⅔ ft.	200 r.p.m.	4 h.-p.
Auditorium ..	38,000 "	9x5 "	120 "	14 "
Fifth	13,700 "	5½x3 "	190 "	5 "
Sixth	10,000 "	5x2 "	200 "	4 "
Basement	25,000 "	6x3½ "	220 "	13 "
Exhaust.				
Base. & 1st...	35,000 "	7 "	200 "	15 "
Auditorium ..	38,000 "	7 "	200 "	15 "
5th & 6th.....	22,000 "	5 "	275 "	7 "
Toilets	5,500 "	3½ "	300 "	4 "

TEMPERING COILS AND EVAPORATING COILS OF HUMIDIFIERS.

Floor.	1st Floor.	Auditorium.	5th Floor.	6th Floor.
Tempering.	620 sq. ft.	1,800 sq. ft.	830 sq. ft.	620 sq. ft.
Evaporating	36 "	90 "	42 "	36 "

The fresh air intake is a down-take shaft 4½ x 20 ft. in section, which rises from the filter chamber in the front part of the basement to an opening at the street level into the driveway on the east side of the building near the front. The opening is protected by a 1-in. mesh copper-wire screen and is provided with a Kinnear rolling shutter for closing when systems are not in use. The filter chamber in the basement contains three groups of air filters, one serving the auditorium and fifth floor systems, another the sixth floor and basement systems, while the third serves the main floor entrance hall section. The filters are of the zig-zag cheesecloth type, consisting of filter frames 3½ x 4 ft. in size, and three frames high, held in copper supports stiffened by T-irons and built tightly into the floor and ceiling. The frames are of wood with a copper wire netting to form the backing for the cheesecloth, and are fastened so as to be air-tight in the supports by buttons, which enable them to be removed readily. The total area of the filtering medium is 3,600 sq. ft. which, at the maximum capacity of the fans, permits filtering velocities not to exceed 30 ft. per minute. Each air supply apparatus has a Kinnear rolling shutter for closing it off from the intake chamber when desired. The filter equipment has a set of filtering frames in duplicate, and a motor-driven filter cleaner, consisting of two cleaning hoppers by means of which the dust and dirt are removed from the screens by drawing air through them in a reverse direction. The cleaning outfit consists of a Monogram exhauster, driven by a 3-h.-p. motor, which discharges to the roof through a 6 x 27-in. riser duct. It has intakes to cleaning hoppers at either end of the filter chamber, on which the screens are laid and whipped in cleaning. These hoppers have screen covers for the cheesecloth to rest on, and have bypass openings in their exhaust ducts for relief of air pressure when removing the filter frames.

The tempering coils in the systems supplying the upper floors are in the ducts from the filters to the fans, and, in order to insure the return of all water of condensation by gravity, have been given elevated locations. The tempering coil casings connect with the upper portions of the filter chamber, and are arranged to leave a clear space of 8½ ft. below the coil casings for access to the blowers. Platforms are hung below the casings to give access to the valves and connections and to the air-moistening apparatus. The tempering coils have been made up of two-row sections of 1-in. pipe screwed into separate cast iron headers on the steam and return ends, of the standard Sturtevant construction, and their heating surface is indicated in the accompanying table. The steam supply is in all cases made through two separate headers, one supplying two or three sections and controlled as a unit from a cold air thermostat in the cold air intake; and the other supplying four sections which is controlled by thermostats in the tempered air duct. Each of the individual sections on these headers is valved for further adjustment.

Air moistening apparatus for increasing the humidity of the air delivered to the upper floors has been provided. Copper evaporating pans have been installed in the ducts between the tempering coils and fans, in which water is kept at a constant height by float valves, and is evaporated by steam coils in the pans. These coils are operated by motor valves controlled by Johnson humidostats for automatically maintaining the proper rate of evaporation. The air passages are also provided with accurate thermometers of large size, with bulbs extending into the air passages and also hygrometers of the "hygrodeik" pattern, with both dry and wet bulbs extending into the air passages. There is, in addition, a thermometer and a hygrometer inserted through the wall in the cold air chamber by means of which, in conjunction with a similar instrument in the air ducts, comparisons of the duty of the tempering coils and air-moistening apparatus may be made.

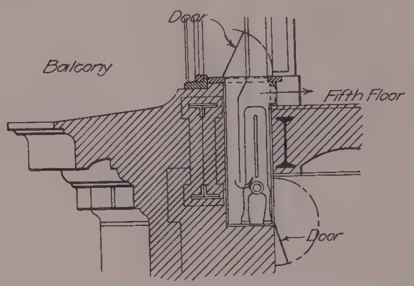
The duct connections for the system supplying the upper floors are carried on the ceiling of the basement from the fan outlets to four groups of shafts, one at each corner of the building. The two at the front corners provide for ducts carried up to the third, fourth, fifth and sixth floors, which results in short direct connections from the fans, located in the front portion of the basement underneath. The shafts at the rear accommodate the supply risers for the entrance hall and rooms on the first floor. The distributing ducts for the first floor system as well as also the basement cold air supply system ducts are carried on the ceiling of the basement. The tempering coil and fan casings, and also all air supply ducts and stack casings in the basement, are covered with 1-in. magnesia blocks cemented and covered with 10-oz. canvas. The riser and distribution ducts are covered with 1-in. air cell asbestos covering similarly cemented and canvas jacketed.

The duct connections to the first floor are made in general through furred partitions on the front and rear sides, through which short risers are carried up from the basement distributing flues. There are fifteen outlets, five of which are registers located at the ceiling and the remainder near the floor line. In addition there are outlets from this system supplying the four auxiliary rooms on this floor, two at the front and two at the rear. A feature of the first floor system is the provision of indirect heating, which was necessitated by lack of available space for radiators in the entrance hall. Seven of the supply branches of this system are provided with indirect heating stacks to reheat the air supply. The stacks are all six-section cast iron heaters having 72 sq. ft. of radiation and are suspended with their casings from the ceiling of the basement. The casings are of No. 20 galvanized iron supported on angle iron framework and the whole heavily covered with heat insulation.

The auditorium system, supplying the second, third and fourth floors, has a 54 x 72-in. riser duct in the forward corner duct shaft to the ceiling above the auditorium, where an extensive system of distributing ducts delivers air to outlets in the auditorium ceiling, the ventilation of the auditorium being on the downward system. There are three transverse groups of outlets in the paneled ceiling, each with eighteen outlet openings. These openings are supplied by transverse branch ducts from a longitudinal distributing duct over the gallery promenade on the front side. There are also supply openings into the main hall on both the third and fourth floors into the promenade corridors at both the front and rear and into the passages at the rear of the stage.

The fifth and sixth floor supplies consist of riser ducts carried up in the front corner duct shafts, which supply distributing systems located above the furred ceilings. A small assembly room on the fifth floor has four outlet registers while a larger room has six, all of which are top registers for downward supply. Three lecture rooms on the sixth floor are similarly supplied by top registers, of which there are two to each room.

Foul air is removed from the building by four disc exhaust fans in pent houses on the roof, to which the exhaust ducts are carried. One system operated by a 7-ft. fan serves the basement and entrance floors; a second operated by a 7-ft. fan serves the auditorium; the third, operated by a 5-ft. fan, is for the assembly and lecture rooms, and the fourth system, operated by a 3½-ft. fan, is for the toilet rooms. These exhaust fans are all Blackman disc fans located directly in the spaces of the roof discharge caps and direct-connected to special C. & C. vertical shaft motors on the floor below. The fans draw directly from riser shafts carried from the exhaust gathering systems on the lower floors to the attic, where they join into large exhaust flues connecting with the fans. The basement and first floor systems are located at the westerly side of the attic, the riser ducts being carried up through shafts at the westerly side, while the fifth and sixth floor and auditorium systems are arranged in the easterly pent house for direct-connection to the exhaust risers from those floors.



Radiator Pockets, Fifth Floor.

The exhaust connections for both the fifth and sixth floors are made from a gathering duct system carried above the furred corridor ceiling of the sixth floor, branch connections being carried down through partitions to the sixth and fifth story bottom registers. The auditorium exhausts through a gathering system above the ceiling of the gallery promenade and in the second floor space underneath the sloping orchestra floor; the former draws from openings into the gallery and gallery promenade corridors at the fourth floor level, while the latter system has branch ducts exhausting from the coat room enclosure on the second floor and from top and bottom exhaust registers on the main floor of the auditorium. Both the first floor and basement exhausts are provided for in a common gathering system on the basement ceiling, connections to the first floor being made through short branches to registers near the floor line while the boiler and machinery rooms have top openings for removal of the heated air.

Both the direct radiation and the tempering and indirect heating coils are under automatic temperature control on the Johnson thermostatic system, there being installed in the building 225 thermostats which control 319 heat sources. These are distributed as follows: In the basement, two cold air and four hot air thermostats controlling the four tempering coils and one hot water thermostat controlling the hot water heater; on the first floor, fourteen thermostats controlling nineteen radiators and eight double dampers of the indirect heating ducts; on the second floor, eleven thermostats controlling thirteen radiators; on each of the third and fourth floors, eleven thermostats controlling twenty-one radiators; on the fifth and sixth floors thirteen thermostats controlling twenty-two radiators; on the seventh and eighth floors, nineteen thermostats controlling twenty-five radiators; on the ninth, tenth and eleventh floors, twenty-three thermostats controlling twenty-four radiators, and on the twelfth, thirteenth and fourteenth floors, which are devoted to the library, forty-one thermostats controlling fifty-four radiators and four pneumatic appliances operating seven skylight coils. The tempering coils of the fresh air supply systems have a duplicate system of temperature control with both cold and hot air thermostats, the former being located in the cold air intake chamber and controlling the two outside coil sections of each heater, to provide against freezing in extreme cold weather; the hot air thermostats are located in the main fan delivery duct connections, and serve to adjust the temperature of the air for delivery to the rooms, controlling the remaining inside coils of the heaters.

The heating and ventilating plant of the Engineering Building, together with the provisions for such power plant as may be provided at a future date, has been designed by, and installed under the supervision of, Mr. Alfred R. Wolff, consulting engineer, New York. The heating and ventilating equipment was installed by G. A. Suter & Co., New York. The architects for the building were Messrs. Hale & Rogers, and Mr. Henry G. Morse, associate.

The State Control of Waters is strongly urged in the annual report of the New York State Water Supply Commission. This refers not only to such a regular examination of water supplies for potable purposes as shall insure the detection of any serious change in their quality, but also to the larger problem of the regulation of stream flow in order to prevent floods. The Commission believes that it is unwise to allow the appropriation of potable waters for power purposes, except under such State supervision and regulation as is at present exercised in the case of water-works plants. The diminution of floods, the report states, could be brought about by the construction of reservoirs which need not flood public forests, an act prohibited by the constitution, and the waters stored in these reservoirs might be made a source of revenue. Whether the Commission has formulated any definite plans for legislation to carry out its suggestions is not apparent from the portions of the report recently made public. The general proposition, however, that the State should exercise an equitable supervision and control over the unappropriated waters of the State is a good one. The time is coming quickly when water powers and water supplies will be appraised much higher than now, and any failure to secure State control of them, so far as they are now unappropriated, is unfortunate.

The Making, Indexing and Filing of Drawings.

A paper read before the Illinois Society of Engineers and Surveyors by Mr. J. J. Harmon.

This paper was not prepared for the purpose of presenting new and revolutionary methods, but rather with the idea of describing some of the methods which have come under my observation and have proved well adapted to the requirements. Drawings are of many different kinds and for widely different purposes, consequently detailed rules which apply to one might be of little or no value for another. However, the same general principles, with proper modifications of the details in the different classes of work, should maintain, whether the work be mechanical, structural, railway, architectural or otherwise. Being a mechanical engineer, I shall deal chiefly with that class of work in this paper.

The working drawings for a machine are primarily projected pictures of it, usually a front, a top and a side view; although in many cases all three views are not required, and quite often a complicated bit of construction is shown by sections and special views. This, however, is only the foundation work of the drawing; the real structure consists of the dimensions and explanatory notes superimposed upon the picture, making, when complete, an illustrated sheet of instructions for the workman.

The purpose of the drawing is, of course, to furnish the workman with detailed instructions for making the part. Usually there are at least two or three different kinds of work involved in making a machine part; consequently, several copies of the drawing are required at the outset and new copies of the drawing may be required for various purposes at later dates. Then in order for a working drawing properly to fulfill its mission, it must not only furnish instructions to the workman, but it must also be capable of easy duplication, and be so made that it can be indexed and filed away according to some convenient system.

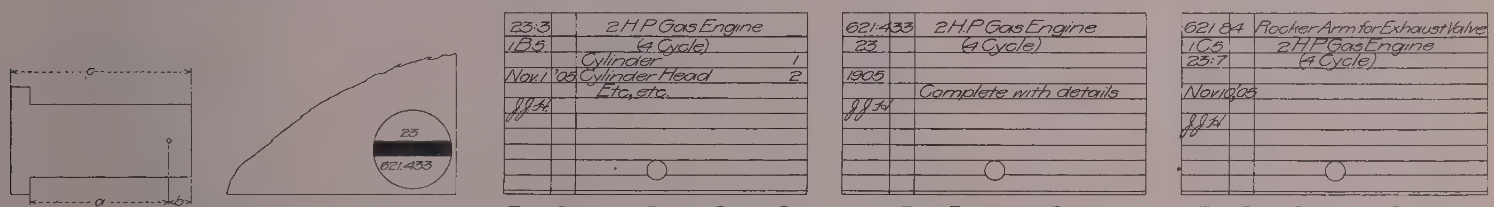


Fig. 1 Dimensions of a Cotter Pin   Fig. 3 Method of Numbering Sheet   Fig. 2 Sheet and Pattern Record Card   Fig 4 Reference Card   Fig. 5 Cross Reference Card

Diagrams Illustrating Methods of Lettering and Indexing Shop Drawings.

In order to fulfill these conditions, all working drawings, as soon as they have passed out of the experimental stage, should be traced on tracing cloth. These tracings should be of standard sizes, for a convenient system of indexing and filling a large number of odd size drawings is well nigh impossible. The standard sizes used by the Mechanical Engineering Department of the University of Illinois are based on the double elephant sheet, the largest size being 26 x 40 in., the smaller sizes being obtained by cutting the sheet in half and ranging down as follows: 20 x 26, 13 x 20 and 10 x 13 in. Another standard, 8½ x 11 in., which is letter-paper size, is used for drawings which are to accompany correspondence. There is also another system of standard sizes in very common use which is based on a 24 x 36-in. sheet, the other sizes ranging down as follows: 18 x 24, 12 x 18, 9 x 12 and 8½ x 11 in.

For detail drawings the small sheets with few parts on them have many points of advantage over large sheets with many parts on them. The workman is not required to handle such a large sheet; the prints last longer, because they are not in such constant use; and, when a part is changed so that a new drawing must be made, there are fewer parts to trace in making the new drawing. Some companies have even gone so far as to make it a rule that only one part may be detailed on a single sheet.

In order to obtain uniformity in the drawings of a certain office, not only the size of the sheets should be standard but also the character of lines, size of figures and lettering, manner of applying dimensions, and the like.

Standard titles should also be adopted. A common arrangement for a title is: first, the firm name and its location, then a descriptive title of the drawing, followed by the scale, the date, and the signatures of the draftsman and the checker. This title should always be located in the lower right-hand corner of the sheet.

Too much cannot be said regarding the proper dimensioning of a working drawing. The essential dimensions should all be present, but the non-essential ones should be left off, for too many dimensions are certainly just as undesirable as an insufficient number. I have seen drawings of both kinds go into the shop, and both give the workman a great deal of trouble. In order to be able to determine what dimensions are essential and what non-essential, a draftsman must have sufficient familiarity with shop methods to be able to picture in his imagination the operations necessary for making the part in the shop, following through the work in his mind's eye from the time the drawing leaves the drafting room until the piece is completed.

Even so small a thing as improper dimensioning of the drawing may seriously effect the shop cost of an article. Suppose a machine part had one important dimension which was required to be a certain distance exactly, while other dimensions on the same piece might vary considerably without affecting its utility; it would evidently be rank foolishness to dimension this part in such a way so to lead the workman to believe that all the dimensions were equally important.

A common example of this is shown in Fig 1; *a* is an important dimension, while *b* may vary within rather wide limits. Therefore, *a* should be given and *b* left off, *c* should be given so that the length of the pin will be known. It is the practice in some drafting rooms to place a small *f* before dimensions such as *a*, in order to indicate that it is an important dimension and should be satisfied within rather close limits.

In dimensioning the drawing of a casting, I have found it to be a great help to classify the required dimensions as follows: First, put on the dimensions required by the pattern maker; and then add those required for finishing the piece in the machine shop. The number of dimensions required by the pattern shop will usually be far in excess of those required by the machine shop, and some drafting rooms follow the practice of putting only those required by the machine shop on the drawing, those required by the pattern shop being placed on a single blue print with an alkaline solution of some kind. However, this practice has a very serious objection in the fact that should this one blue print ever be destroyed or lost, which might happen quite easily, there would be no second of the pattern dimensions.

Another class of dimensions, which it is occasionally desirable to place on a drawing, are those of interest to the drafting room alone, such as distance between bearings, center to center, etc.

Dimensions should always be given in convenient fractions of an inch, such as ⅛, 1/16, 1/32 or 1/64; the fractions 1/3, 1/5, 1/6, etc., should never be used, as machinists' scales are not graduated to these dimensions. Decimals should only be used when great accuracy is required. Draftsmen should avoid giving dimensions with greater accuracy than is necessary, and should always be sure that they can be satisfied in the shops with ordinary workmanship; e. g., never give a dimension between rough, unfinished surfaces in smaller fractions than 1/16 of an inch unless it is very small work.

When using stock material, care should always be taken to specify standard sizes.

Parts should always be named and numbered, and both the name and the number should appear on the drawing below the views. In naming parts do not choose names which involve the material of which the part is made, such as "Cast Iron Block" or "Brass Washer," for at any time it may be found advisable to change the block to one of wrought iron or cast steel, and the brass washer to one of fibre. This would be a serious matter in a manufacturing concern, as the names would have to be changed on the drawing, in the catalogues, repair lists, bills of material and many other places.

A bill of material should contain the name and number of every piece used in the machine, as well as the material of which each piece is made, the number of times it is used in a complete machine, the sheet number of the drawing on which it appears, and any other items which particular conditions may make important.

Standard parts, such as bolts, nuts, screws, etc., are not drawn or numbered, however they do appear in the bill of material, unless they are isolated in a separate list called a standard list.

It is the custom in some drafting rooms to place these bills of material on a sheet with some of the details, while in others they are placed on a sheet by themselves, and in still others they are made out by the draftsman and typewritten copies of them furnished to the different departments.

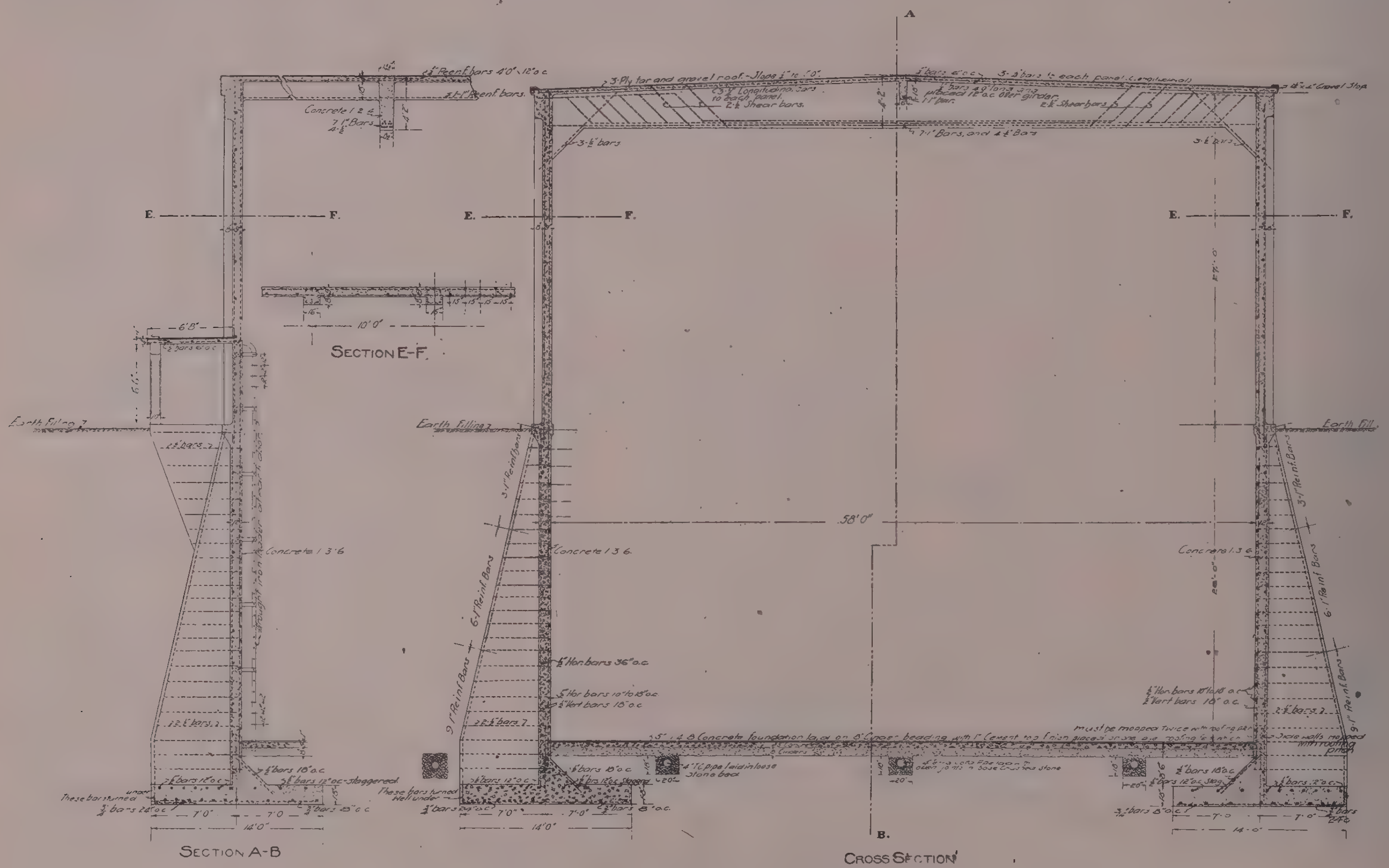
Most drafting rooms of manufacturing concerns leave an extra wide margin either at the left hand or lower edge of a drawing, for the purpose of inserting explanatory notes in regard to changes which are made on the sheet from time to time.

When a drawing is completed, it should be very carefully checked over, either by the man who made it or by a checker, before it is allowed to go into the shop. It is a great help in checking drawings to outline first a standard method of doing the work, jotting down special mistakes which are likely to occur, etc. It will probably be necessary at first to make changes in and additions to the outline, but when it is perfected it will undoubtedly add greatly to the speed and effectiveness of checking.

Intelligible notes should always be kept of all calculations of dimensions taken from reference books or previous successful designs, and of any important points which it may be desirable to preserve. These notes should always be headed with the date, the name of the work to which the notes apply, and the name of the designer.

The methods of indexing and filing are numerous, and it cannot be said that any particular method is the best; because the conditions are so dissimilar in different drafting rooms that a perfect system for one might be very poor for another. In devising a system for indexing and filing drawings, the requirements peculiar to the particular case under consideration should be analyzed and carefully studied before deciding upon the basis of classification.

To illustrate the difference in conditions which may occur, I will briefly outline the conditions as they exist at two places with which I am familiar, and the systems which are in use at those places. The two places which I have in mind are the drafting room of a certain large factory and the Mechanical Engineering Department of the University of Illinois.



Fertilizer Tankage Building at Atlanta, Ga.

Let us first take up the system used in the drafting room of the factory. This is a firm manufacturing a line of agricultural implements, such as binders, reapers, seeders, mowers, etc. In speaking of the system used by this firm, I shall use the past tense, because four years have elapsed and the factory has changed management since I was connected with it, so it is somewhat doubtful whether the same system still survives. The following were the governing conditions which formed the basis for their system of indexing and filing. The drawings were used continually, and as they were likely to be wanted at any time, it was necessary to have a convenient index for quickly locating them.

There were large numbers of drawings to be taken care of, and the drawings for any particular machine were so numerous that filing by machine would not have been at all satisfactory. The condition which formed the basis of the index was the fact that each and every part had a repair list number, and was known by that number rather than by name. The method used was as follows:

Each drawing when completed was recorded in the drawing record book, and was given a serial number; thus all possibility of two drawings being marked with the same number, or of any drawing ever being lost without the knowledge of the drafting room was prevented.

The standard sizes for sheets were 24 x 36, 18 x 24, 12 x 18, 9 x 12 and 8½ x 11 in., and they were designated by the numbers 1, 2, 3, 4 and 5 respectively. Each one had a separate record book, and a separate series of numbers starting from unity.

Drawings were also made in the tool room, so in order to distinguish drafting room from tool room drawings each sheet was marked with the letter *D*. The number of a drawing then consisted of three parts, the number designating the size of the sheet, the letter designating the source of the drawing, and the serial number; thus, 3 *D* 578 signified that the sheet was 12 x 18 in., was made and on file in the drafting room, and was the 578th sheet of that size to be recorded. This number was placed in the margin of the drawing outside of the border line, in both the lower right hand and the upper left hand corners. The number in the upper left hand corner was inverted, so that should the sheet by any chance become inverted in the drawer, the number would still be found at the lower right hand corner of the pile of drawings.

The drawings were filed in drawers slightly larger than the sheets, and the order of filing was that of the serial numbers, running up from the bottom of the drawer to the top.

The method of indexing was by a card system based, as was mentioned before, on the repair list numbers of the parts. These cards were standard 3 x 5-in. cards, and, as they were arranged in the order of the repair list numbers, were easily located in the index. The body of the card contained the name of the part, and the number of the sheet on which it was to be found.

Another rather serious problem which had to be dealt with in this particular case was the care of blue prints. A supply of prints was kept constantly on hand, because the shop foremen were likely to come in at any time for a print of a certain part, and they always wanted it at once. When they were through with it they would return it to the drafting room, where the prints were kept on file in precisely the same way as the drawings. It was necessary also to keep a complete record of all blue prints from the time they were made until they were destroyed; on account of the fact that changes in drawings were being made constantly, and whenever this occurred all the blue prints had to be called in and either destroyed or changed to correspond to the new drawing. This record was kept on 3 x 5-in. cards. A record card was made out for each sheet, and by referring to it, one could determine at any time just how many blue prints were out, and just where they were located.

The conditions existing and the system in use in the Mechanical Engineering Department of the University of Illinois are entirely different. In the first place the class of work there is much wider in scope and then the repair list numbers which were so convenient for indexing in the former case are in this case lacking.

The machine design department, which is the main source of drawings, does not keep blue prints of the tracings on file, but simply furnishes them from the originals when required. This department does have on file, however, a large number of prints which have been obtained from manufacturers for the aid of students in design work. The tracings made by the department are naturally much more important than the prints, and consequently a more detailed system of caring for them is used. The card system is used for the record instead of a record book.

The record number is made up of two parts, a machine or general number and a sheet number. The machine numbers form a single consecutive series, and the sheet numbers form subseries for each machine.

With this system drawings may be made and filed in the department where they are to be used if it is so desired. The record cards are so filled out that they serve as a record of the pattern numbers as well as the sheet numbers. Fig. 2 is a sample card. The record number of the drawing is 23.3, 23 being the machine number and 3 the sheet number. Likewise the pattern number of the cylinder is 23.1, 23 being the machine number and 1 the number of the part.

In the designation 1*B*5, the 1 signifies the department where the drawing was made and to which it belongs, while the *B* signifies the number of the sheet, and the 5 signifies the drawer of the filing cabinet in which the drawing is kept. The drawings, of course, are filed away in the order of the machine and sheet numbers.

Should more than one record card be required for listing the parts contained on a single sheet, the succeeding cards are filled out in exactly the same way as the first, but are on blue paper instead of white.

The method of placing the number on a sheet is shown in Fig. 3. The black strip in the center of the ring leaves a white space on the blue print, upon which the owner of the print may write his name or the number of his department.

The index is kept on 3 x 5-in. cards and is based on the Dewey decimal classification. The Department of Mechanical Engineering at the University of Illinois has prepared quite an elaborate extension of the number 621, which represents Mechanical Engineering, and by the aid of this extension it is possible to separate the different classes of machinery into rather small divisions. I might say in passing that this extension is used quite generally in the Mechanical Engineering Department for indexing all kinds of matter, and has proved very satisfactory.

In the drawing index a card is made out for each machine, and cross reference cards are made out for such parts as have a different Dewey number from that of the machine itself. Figs. 4 and 5 are samples of the two kinds of cards.

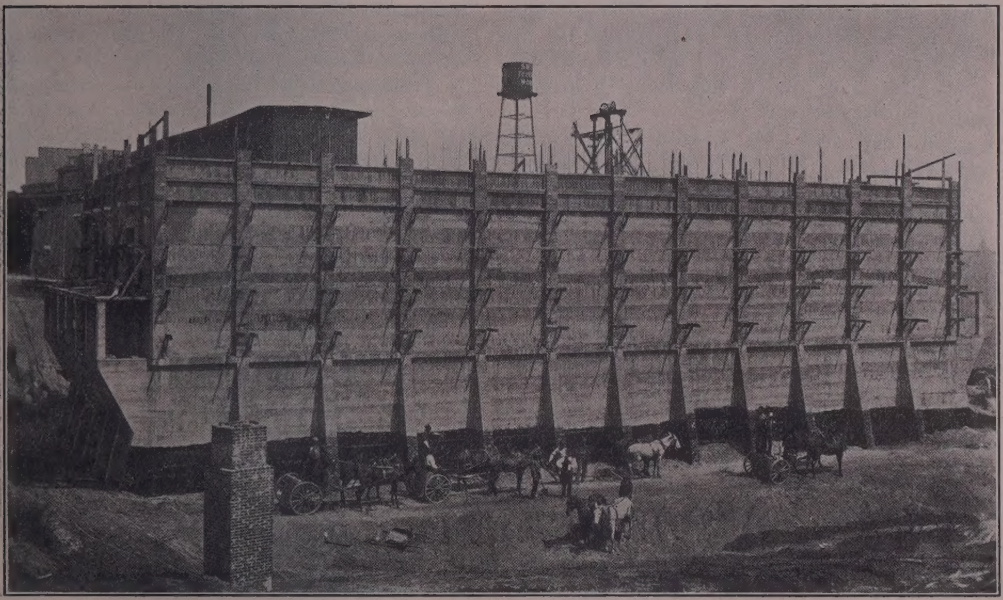
This method of indexing decreases materially the volume of the index below that which would be required were a card filled out for each and every part. It is also fully as efficient in locating the drawings, because after the machine number is determined, the drawing of any particular part may be found from the bill of material or from the record cards. The bill of material is always the first sheet. Parts are numbered in the order of their size, and cost parts are detailed first, then forged parts, and last, parts made of wood, fibre, etc.

Blue prints coming from outside of the Department are marked by pasting a white circular tag 1¼ in. in diameter in the lower right hand corner, upon which the Department and Dewey numbers are placed. The blue prints are then filed away in drawers by the Dewey numbers, irrespective of size of sheets. No index is necessary.

This system is not as convenient for locating a particular drawing as the others and does not provide against loss of sheets. However, the labor of indexing and filing is considerably reduced, and all of the drawings of a certain class of machinery are kept together, so it serves its purpose very well.

The Tankage Building for the Swift Fertilizer Works, Atlanta.

A reinforced concrete building, 60x120 ft. in plan and about 50 ft. high from the floor surface to the bottom of the roof girders, consisting simply of four enclosing walls and a roof, has been built at the Swift Fertilizer Works, Atlanta, Ga., for the storage of a by-product of the stock yards, called "tankage," which is shipped in bulk and is the base of some commercial fertilizers. As this material was to be handled by overhead conveyors and belt elevators it was desirable that the building be built as a shell without intermediate floors or interior columns. In addition to meeting these conditions it was also necessary to design the walls to resist the pressure of a fill of loose earth, the surface of which, at the walls, is 26 ft. above the floor level.



Backfilling 12 Ft Above the Floor Level of Tankage Building.

The end and side walls are alike in design. Below the surface of the fill the walls are 12 in. thick and are divided into sections by counterforts placed 10 ft. center to center. The steel reinforcement is proportioned according to the depth of the fill, as is shown in the accompanying general cross-section of the building. At about the level of the top of the fill a water table extends around the building and above this the walls are only 9 in. thick. Here, reinforced pilasters 16 in. wide and 8 in. thick, placed 10 ft. center to center and directly above the counterforts, give additional strength. The wall footings are reinforced and extend outward 7 ft. to the outer line of the counterforts and inward 7 ft. under the floor, both measurements being made from the center of the 12-in. wall. These footings are in general 1 ft. 8 in. thick and are reinforced in both the top and bottom surfaces. They are designed to take advantage of the weight of the earth fill in resisting the overturning moment due to the lateral pressure of the earth. In the walls and footings 1:3:6 concrete was used and new-style Johnson bars of high carbon steel were used throughout the structure.

The floor is of plain concrete, mixed in the proportion 1:4:8, 5 in. thick and laid on a bed of cinders 8 in. deep. Over the surface of the concrete was laid one layer of roofing felt. This was mopped twice with roofing pitch and a top finish of 1 in. of cement was then applied. The outside of the walls was also mopped with roofing pitch below the water table. Three longitudinal lines of 4-in. terra cotta pipe, laid with open joints in crushed stone, under the floor and a similar line just outside the counterforts on each side of the building, drain the foundation soil.

The roof has a pitch of ¼ in. in 1 ft. from its longitudinal center line and consists of 4 in. of reinforced concrete covered with three-ply tar and gravel roofing. It is supported on 1:2:4 reinforced concrete girders, 13½ in. thick, 4 ft. 2 in. deep at the center, including the thickness of the roof, and having a clear span of 58 ft. from inside to inside of the side walls. These girders are spaced 10 ft. center to center. In the lower portion of each girder are seven 1-in. and four ½-in. bars, and at each end are ½-in. shear bars, arranged as shown in the accompanying illustration. A longitudinal girder 6x18 in. in section, not including the thickness of the roof, is placed immediately under the ridge of the roof and connects the main girders. It is reinforced with one 1-in. bar in its lower surface.

In building the walls the forms for the counterforts and pilasters were built in position and securely braced to act as guides and supports for movable forms which were used for all curtain walls between the pilasters and counterforts. These movable forms were built in sections 32 in. high, each section consisting of two 3x4-in. stringers to which ⅞-in. matched flooring was nailed. Two sets of these forms were provided for each bay, and were alternately removed and replaced above each other. Ordinarily the concrete was allowed two days' set before the forms were removed.

The building was designed and built by the Southern States Reinforced Concrete Co., of Atlanta, Ga., of which Mr. George B. Hinman is president and Mr. A. Francis Walker is engineer. Johnson's corrugated bars and Whitehall Portland cement were used throughout the structure.

The Refuse-Burning Plant supplying steam to the electric lighting plant of the Williamsburg bridge at New York was recently given a 6-hour test under the direction of Prof. G. F. Seaver, of Columbia University, and Mr. F. L. Stearns, of the Department of Street Cleaning. The plant, which was described in detail in The Engineering Record of Nov. 11, 1905, has two 200-h.-p. Stirling water-tube boilers. The total refuse burned during the test was 40,497 lb. or an average of 6,749 lb. per hour. In volume the quantity burned was 293 cu. yd., weighing 138 lb. per yard. The total grate area is 192½ sq. ft. and on each square foot 39.2 lb. of refuse was burned per hour. The heating surface is 3,780 sq. ft. and the steam pressure during the test was 143 lb. For each pound of refuse 2.29 lb. of water was evaporated from and at 212° F., and 46 lb. of rubbish was burned per kilowatt-hour. The high amount of water evaporated per pound of refuse is largely attributed to the economizer. The large amount burned per kilowatt-hour, 46 lb., is due to the fact that the boilers were run at full capacity, but not all the power was used in generating current.

T-Rails and Grooved Rails for Paved Streets.

The problem of railway construction in city streets is engaging such widespread attention among city engineers and street railway officials, that attention is called to two recent papers dealing particularly with the question of the proper rail section for use in paved streets. One of these papers prepared by Mr. C. Gordon Reel, vice-president and general manager of the Kingston Consolidated R. R. Co., Kingston, N. Y., was read before the New York State Street Railway Association last month. Mr. Reel strongly favors the T-rail and called attention to its principal points of superiority as follows: It is symmetrical in section and the load comes directly over the center of the rail. It has unlimited flangeway and its full, deep head insures long life. It is easily spiked to the ties. The long angle-bar joint with T-rails is nearly perfect. The track does not tend to spread or move about in the street and loosen the pavement. The flangeway being gritty a vehicle can turn out of the track easily. T-rail track is less noisy than some other types. The standard rail sections, according to Mr. Reel, are preferable to the high T-rail sections, being more substantial, more easily held in place and cheaper.

The other paper is a report on street railway rails and track construction, prepared by Mr. Frederick L. Ford, city engineer of Hartford, Conn., for the Board of Street Commissioners of that city. Mr. Ford favors the use of grooved rails in Hartford in all paved streets and believes that the proper rail section lies between the section used in Hartford and the new "Boston standard" grooved rail. According to Mr. Ford, use of the T-rail is increasing in the West and Northwest. This, he says, is because many of the streets in those cities are 75 to 100 ft. wide between the curbs, so that it makes little difference what kind of track construction is used, provided that it will withstand the street railway traffic. The space occupied by the tracks is practically unused by vehicles except at street intersections or where teams are obliged to cross it. Moreover, the length and severity of the winter seasons in those localities makes the question of snow and ice in grooved rails more important than in the Southern and Eastern cities. For exactly opposite reasons the grooved rail has become practically the standard in Eastern cities, and T-rail construction will never be greatly favored in the opinion of Mr. Ford. The Eastern cities have street systems which are notoriously narrow and crooked, and can not sacrifice entirely for railway purposes the space necessary for their tracks.

Both of these papers contain letters, nearly all written in 1906, received from city engineers and street railway officials and giving information in regard to the present practice in various cities. From an examination of these letters it appears that the following cities are among those in which the T-rail is at present generally used for new work: Dayton, Ohio; Davenport, Iowa; Delaware, Ohio; Denver, Colo.; Erie, Pa.; Indianapolis, Ind.; Kansas City, Mo.; Milwaukee, Wis.; Minneapolis, Minn.; New Haven, Conn.; Ottawa, Can.; St. Paul, Minn.; Schenectady, N. Y.; Scranton, Pa.; Tacoma, Wash.; Terre Haute, Ind.

From the letters received by Mr. Reel and Mr. Ford, from city engineers who favor the use of the T-rail, the following extracts have been taken:

Amsterdam, N. Y.: Mr. F. E. Crane, city engineer says: "We have in this city brick block pavement laid along 70-lb. T-rail. This pavement is laid on a concrete foundation with a thin layer of sand. It has been laid since 1900 and is on the street of our heaviest traffic. This pavement shows no tendency to wear in ruts."

Dayton, Ohio: Mr. Robert E. Kline, city civil engineer, says that in the past five years T-rail has been adopted in Dayton and used on all track construction where street paving is contemplated or used. The construction has been satisfactory in every respect.

Delaware, Ohio: Mr. J. S. Dike, city engineer, states that in Delaware a 4-in. T-rail is used, raised on a 1-in. block. Special paving block are used to form the flangeway and a special filler brick is placed next the web of the rail. Mr. Dike says: "We like this construction better than grooved rail and have never had any trouble except with a car or two which had a very narrow tread which broke a few of the stretcher brick."

Indianapolis, Ind.: Mr. Blaine H. Miller, city engineer, states than when the new franchise was arranged with the Indianapolis Traction and Terminal Co., tests were made to ascertain which rail was best for all purposes. The result of the test indicated that the 90-lb. T-rail combined the good qualities of the old grooved and girder rails. These rails were not used except in unpaved streets for some time after the new rail was adopted, but now the use of special grooved vitrified brick has made it possible to use heavy 90-lb. T-rail in permanently improved streets with quite a saving in repairs, especially since the heavier interurban cars have entered the city. This rail is being substituted for the old grooved and girder rails, and is considered an improvement in every respect.

Milwaukee, Wis.: Mr. Charles J. Poetsch, city engineer, says: "The Milwaukee Electric Railway & Light Co. is giving an interurban service in connection with the city lines. The rail that this company uses on its new construction is the T-rail. Formerly the rail was 6 in. high and weighed 72 lb. to the yard, but the rail as now adopted is 7 in. high and weighs 95 lb. to the yard, the head is 3 in. wide, and the base 6 in. In constructing asphalt pavements the street railway company furnishes the contractor with the granite blocks which are placed inside the inner and outer side of the rail. The gauge has a granite head which is grooved by dressing a quarter round of the stone to permit the wheel flanges to travel. With brick pavements we now lay the brick low enough on the inside to clear the flange, and the other end inclined up so as to meet the crown of the pavement between the two rails. This construction permits teams to cross freely at all points along the line, and we never had any trouble or complaints. Of course the teams cannot follow the gauge line of the track, but in large cities we do not want them to drive ahead of the cars as the people desire rapid transit, and slow-moving teams must keep off."

Minneapolis, Minn.: Mr. Andrew Rinker, city engineer, says: "The street railway company of this city now uses T-rail exclusively. It is the best rail for the purpose and the public interests are better subserved by its use." The rail used in Minneapolis weighs 80 lb. per yard. It is laid with cast joints and is spiked to wooden ties bedded in concrete.

Ottawa, Canada: Mr. Newton J. Ker states that the T-rail is used on all tracks in Ottawa. He says: "In recent years the old rails have been replaced with the 90-lb. standard T-rail in 62-ft. and 64-ft. lengths, and have proved very satisfactory. Wherever we lay permanent pavements these rails are laid on 6 in. of concrete. The ties spiked 8 ft. apart and embedded in concrete. The paving blocks are specially cut to fit under the rail and to allow the flange of the wheel to run freely."

St. Paul, Minn.: Mr. L. W. Rundlett, Commissioner of Public Works, speaking of the T-rail used with grooved granite blocks, or a similar arrangement, says: "Our experience with the T-rail, with the constructions mentioned, is highly satisfactory; in fact, I consider it the best possible construction for this climate, where I think a grooved rail would cause trouble."

Schenectady, N. Y.: Mr. J. Leland Fitzgerald, city engineer, approves of T-rail because with a smooth pavement the vehicular traffic tends to avoid the car tracks owing to the frequency and speed of the cars. Mr. Fitzgerald believes that T-rails permit a more solid pavement construction than the wide-flanged girder rail.

From letters written by street railway officials who prefer the T-rail, the following have been selected:

Deleware, Ohio: Mr. Jas. Williams, chief engineer, The Columbus, Deleware & Marion Ry. Co., is strongly opposed to grooved rails because they cause car wheels to wear out rapidly and give a poor contact on account of collected dirt or snow and ice. Mr. Williams has been laying T-rail in brick-paved streets with success.

Milwaukee, Wis.: Mr. Fred G. Simmons, superintendent of maintenance of way, Milwaukee Electric Railway & Light Co., says: "We use Tee rail as our standard construction for both city and interurban work, and find no more difficulty than other roads appear to have in cities where grooved and tram girder construction is the standard."

Scranton, Pa.: Mr. E. D. Reed, engineer, Scranton Railway Co., says: "We are putting in considerable high T-rail track on concrete and paved with vitrified brick, the brick next to the rail being beveled. This is very satisfactory, both to us and the city, were it not for the fact that wagon wheels running in the groove or flangeway soon wear a shoulder in the rail brick, making a wide rectangular slot which is objectionable to vehicular traffic." Mr. Reed believes that granite block properly formed will overcome this difficulty.

Syracuse, N. Y.: Mr. J. E. Duffy, superintendent, Syracuse Rapid Transit Ry. Co., states that 9-in., 90 to 95-lb. girder rail is used in Syracuse, but believes that the T-rail construction is better for all kinds of service.

Terre Haute, Ind.: Mr. G. F. Mets, manager, Terre Haute Traction & Light Co., says his company uses the T-rail exclusively in connection with special bricks laid next to the rail. He says: "We favor T-rail construction under the conditions existing here, and have heard of no dissatisfaction on the part of the city."

Worcester, Mass.: Mr. E. G. Connette, general manager of the Consolidated Railway Co., says: "Ninety-pound T-rail track paved with vitrified paving blocks is the best construction that could be placed in streets, for the reason that the continuity of the rails is not so easily disturbed at the joints, consequently not so much wear and tear to the streets."

Among the cities in which the T-rail is not regarded with favor at present are: Baltimore, Md.; Brooklyn, N. Y.; Buffalo, N. Y.; Cambridge, Mass.; Cleveland, Ohio; Detroit, Mich.; Louisville, Ky.; New York, N. Y.; Richmond, Va.; Rochester, N. Y.; Springfield, Mass.; Washington, D. C.; Waterbury, Conn.; Worcester, Mass.

The following extracts are from letters received from city engineers who prefer the grooved rail rather than that of T-section:

Cambridge, Mass.: Mr. L. M. Hastings, city engineer, says: "With regard to T-rail construction, we have not used that lately, although some of the older track is constructed with what was called the 'Longstreet' girder rail. This rail was 7 in. deep, and I think weighed about 70 lb. per yard. It never was popular or successful. The T-rail is used, however, in reserve spaces with success. Here it is placed upon sleepers with the rails stayed by rods every 5 ft., and the track ballasted with either cracked stone or gravel, surfaced up with loam and sod. This style of construction is very popular, both with the railroad, and where the width of the street is suitable, with the public."

Columbus, Ohio: Mr. Julian Griggs, chief engineer, states that T-rail is considered suitable for unpaved and macadam streets in Columbus, and that there is quite a mileage of this construction in the city on paved streets. He said: "It is, however, impossible to maintain the paving along the Tee rails on streets with any considerable traffic, and our judgment is that its use should be prohibited for paved roadways."

New Haven, Conn.: Mr. C. W. Kelly, city engineer, states that T-rail is used in all street railway construction because efforts to have the grooved rail adopted have been unsuccessful. He says: "I have always been a strong believer in the use of the grooved rail in city pavements, although we have had no direct experience here. We find our asphalt pavements especially expensive in maintenance along the inner side of the rails when laid directly up to the rail. Our brick pavements also, where the traffic is heavy, wear badly along the inner side of the rail."

Rochester, N. Y.: Mr. E. A. Fisher, city engineer, states that there is no T-rail track in the roadways of Rochester, but that this type of construction is used where the tracks are laid between the curb and the sidewalk. Mr. Fisher does not favor T-rail construction in public streets. He says: "I think the least objectionable condition for a railway track in a public street is where the groove is made as narrow as possible, and has a lip on the flange of the same height, or as near as possible of the same height as the head of the rail. The form of rail I refer to is what is known as the "Trilby" or "Metropolitan" rail, as used in the city of New York. We have a considerable amount of this rail, which is satisfactory to the city officials and to the citizens generally."

Springfield, Mass.: Mr. Charles M. Slocum, city engineer, states that several types of street-car rails have been used in Springfield since 1890, but that for paved or macadamized streets all those first experimented with have been discarded and the full grooved "Metropolitan" girder rail adopted. In describing the first experiment with the T-rail, in Springfield, Mr. Slocum said: "The combined action of the car wheels and the wheels of ordinary vehicles rapidly produced deep ruts against the railhead which was decidedly disastrous to ordinary vehicles, and the complaints were loud and numerous on the part of the traveling public against what was commonly proclaimed as a most decided nuisance." Mr. Slocum does not regard the T-rail as suitable for use except in dirt or gravel roads.

Washington, D. C.: Mr. John Riddle, Major, Corps of Engineers, U. S. A., Engineer Commissioner, D. C., says that the Commissioners of the District of Columbia have never approved any but the grooved rail construction, and that most of the rails have been limited to 1 in. width of groove, although in recent years, a few have been permitted with a slightly wider groove.

Waterbury, Conn.: Mr. R. A. Cairns, city engineer, believes that the grooved rail should always be used in paved streets. He says: "There can be no question that the grooved rail offers far less obstruction to the use of roadways by ordinary vehicles than does the T-rail. Nor does it appear from experience here that the groove rail causes an appreciable amount of extra trouble in operation, either from dirt or ice."

Worcester, Mass.: Mr. Frederick A. McClure, city engineer, states that a few years ago several miles of T-rail construction was put in, on streets of considerable traffic in Worcester. The space between the rails and for 18 in. outside was paved, and on the more important streets granite block was used. Mr. McClure says: "No great time elapsed before the tracking of teams had worn the stone blocks at the gauge of the rails several inches in depth, and the breaking of carriage wheels was of frequent occurrence. If a wheel happened to drop into one of these ruts, it was a most difficult matter to get out again without a mishap. It was particularly dangerous to the rapid passage of fire apparatus, and the complaints becoming so numerous its continuous use was out of the usual. Finally it was all taken up and replaced with a heavy girder rail having a tram head, so that to-day within the thickly settled portion of the city there are no T rails in use."

Several street railway officials who favor the grooved rail wrote as follows:

Buffalo, N. Y.: Mr. F. W. Wilson, general manager of the International Traction Co., says: "We do not believe in T-rail track in city streets unless the traffic is very light. We believe in cities of over 300,000 a girder rail, either tram or Trilby type, should be used. In Buffalo we use a semi-groove girder rail with a 2¼-in. head and 1¼-in. depth of groove."

Brooklyn, N. Y.: Mr. M. S. Menden, chief engineer of the Brooklyn Rapid Transit System, says that center bearing rails are prohibited by law in Brooklyn. The latest type of rail used there is a semi-grooved or "Trilby" girder rail 7 or 9 in. deep. The latter section is now used, but the 7-in. rail is to be tried, and Mr. Menden believes that with it, the track will keep its gauge better than with the 9-in. rail. He says: "We use girder rails spiked to 6 x 8 in. yellow pine ties, spaced 2 ft. centers. The tracks are kept to gauge by malleable iron braces and also tie rods. The joints are electric welded, although the earlier tracks were equipped with Weber joints. The ties are imbedded in concrete, granite block paving is laid on this and the interstices are filled with cement grout. Restricted as we are we prefer a grooved girder rail."

Cleveland, Ohio: Mr. Charles H. Clark, engineer of Maintenance of Way of the Cleveland Electric Railway Co., says that in Cleveland there are about forty miles of track laid with the grooved rail and about 200 miles laid with rails of other types. The grooved rail used is section 95-319 of the Lorain Steel Co. Mr. Clark says: "The interurban lines come into this city with 1-in. flange and 3-in. tread. They make sixty miles an hour outside the city limits. Have no difficulty operating the cars over the grooved rails within the city limits."

New York, N. Y.: Mr. M. A. Starrett, chief engineer, New York City Railway Co., says: "I should prefer in a city where the weather conditions are no more severe than in New York to use some form of grooved rail rather than T rail construction, thus obtaining a much better street service; more durable under the effects of vehicular traffic, and requiring less repairs to pavement adjacent to the rails. The rail used in Manhattan was designed to accomplish these results." The type of rail used at present in New York is designated as No. 228 in the Pennsylvania Steel Co.'s catalogue, and weighs 107 lb. per yard.

VENTILATION THROUGH IRON COLUMNS is practiced in a mill belonging to the Pulketh Co., at Preston, England, according to a report recently published by the United States Bureau of Manufacturers. The air is drawn in at the ground level and forced by a fan through a water spray, and then heated by coils in the usual manner. The air is next distributed from sub-ducts below the basement level through the iron columns of the building into the different rooms, the columns being fitted with openings near the top which are provided with suitable registers. The air is exhausted from these rooms through flues built in the brick walls.

Book Notes.

A very readable "practical" book on "American Steam Engineering" has been written by Mr. W. E. Crane, in which he gives information gathered during thirty years' experience in running, erecting and designing engines. He begins with the boiler-room, then passes to mason work and chimneys, and ends up in the engine-room. The book is wholly unlike the ordinary work on power plants, for it begins about where they leave off. It is essentially a description of how to run such a plant, although there is a lot of historical information in it, and many notes on the proper selection of apparatus for particular purposes are given. Taken as a whole, it is a book that anybody interested in power plants, superintendent, engineer or foreman, will probably find it profitable to read. (New York, Derry-Collard Co., $2.)

An excellent volume on "Alternating Currents" has been prepared by Mr. C. G. Lamb for the men taking electrical engineering as one of the subjects for the Mechanical Sciences Tripos at Cambridge University. These students are always among the brightest in the great English university and the book, being prepared particularly for them, is a little above the heads of most students, although there is nothing in it that careful study based on proper preparation for the subject will fail to surmount. The author assumes that the reader is familiar with the general elementary theory of magnetism, including the idea of self-induction, the magnetic circuit, hysteresis and the laws of eddy currents; the principles involved in the action of condensers, the principles of direct-current machines, the elements of the calculus through the definite integrals of simple cases of the circular functions, and the elementary properties of vectors. A knowledge of the elements of the last subject is particularly necessary as the treatment is largely based on it, although analytical methods are used when it is desired to obtain numerical results. No attempt is made to distinguish between absolute and practical units in working out the formulas, although this is done in solving typical numerical examples. The book is distinctively an explanation of principles and there are no descriptions of machinery or details in it. The author modestly disclaims any originality in the contents of the volume, which he calls a compilation, but his self-styled compiling is admirably done and the book is one to be proud of. It states the principles on which the operation of generators, synchronous and induction motors and transformers operate and describes the methods of measurement used in alternating-current work, and is a distinctly standard work. (New York, Longmans, Green & Co., $3.)

The manufacture and use of mixed paints has increased rapidly of late so that about 60,000,000 gal. are now made annually in this country, and one railway company has bought as much as a million gallons in one year. As a result of its use, methods of painting some kinds of products have completely changed, and many manufacturers now dip the pieces to be coated into troughs of paint. Although mixed paints have become so common, very little information has been printed concerning them and the book on "Chemistry and Technology of Mixed Paints" which Mr. Maximilian Toch has written will consequently be welcome to a wide circle of readers. The author's position as a technical chemist and his experience as a paint manufacturer are well-known and make the book particularly important to the engineer. For example, the statements regarding the use of inert fillers in the introductory chapter explain certain features of mixed paints which many engineers have regarded in an entirely wrong light. The author explains the manufacture of mixed paints in the first part of the volume. The next section is on white pigments, oxides of lead and red pigments, and in it are found many statements of the author's opinions of the values of different mixtures for use on engineering structures. Yellow, blue and green pigments are next considered, and then comes a particularly interesting section on inert fillers and extenders. The various paint vehicles are next described, and the descriptive part of the book closes with an account of floor, cement, damp-resisting and brewery paints. The final chapter is on the analysis of mixed paints and there is an appendix on the Chinese oil tree. A large portion of the book deals with subjects in which there is much trade controversy, but the reader will find that the author has taken pains to indicate that his opinions on many things are not universally accepted. The book is an interesting and instructive one on a subject which is not at all well understood. (New York, D. Van Nostrand Co., $3.)

Letters to the Editor.

Transformation of Co-ordinates.

Sir: In land surveying it often happens, after having calculated co-ordinates for all principal points of a survey, that a small change in orientation is made, and that new co-ordinates according to new axes are required. If θ is the angle made by the new axis of X with the old axis of X, x and y the old co-ordinates, x' and y' the new co-ordinates; the new co-ordinates are obtained by the following equations:

$$\left.\begin{aligned} x' &= x \cos\theta + y \sin\theta \\ y' &= y \cos\theta - x \sin\theta \end{aligned}\right\} \qquad (1)$$

θ being small and the degree of approximation necessary being specified, what is the maximum value of θ for which it may be permitted to write $x' = x + \theta y$, and $y' = y - \theta x$.

If we examine the series giving the values, in function of the arc, of $\cos\theta$ and $\sin\theta$, viz.:

$$\cos\theta = 1 - \frac{\theta^2}{1.2} + \frac{\theta^4}{1.2.3.4} - \ldots.$$

$$\sin\theta = \theta - \frac{\theta^3}{1.2.3} + \frac{\theta^5}{1.2.3.4.5} - \ldots..$$

we find that θ being very small, we can put $\cos\theta = 1 - \theta^2/2$ and $\sin\theta = \theta$ without any appreciable error.

Putting these values in equations (1) we have

$$x' = x\,(1 - \theta^2/2) + \theta\, y$$
$$y' = y\,(1 - \theta^2/2) - \theta\, x$$

If the length of the longest line is 1,000 ft., and if the error permitted in making the transformation is not to exceed 1/100 ft., the relative error permitted is 1/100,000. When we put 1 for $1 - \theta^2/2$, the relative error made is equal to $\theta^2/2$, consequently the maximum value of θ satisfying the given conditions corresponds to $\theta^2/2 = 1/100{,}000$, from which we find $\theta = 15' \; 22''$ nearly. If the maximum error permitted should be 1/1,000 ft. instead of 1/100 ft., θ would be found equal to $4' \; 51''$ nearly.

Los Angeles, Cal. G. A. L'Hommedé.

The Ketterlinus Building.

Sir: Is there any mistake in the figures given in your article about the Ketterlinus building in your issue for Feb. 2, or is it really possible that the beams mentioned can carry anything like 350 lb. live load per square foot for over a year without the least sign of failure?

According to the figures given the span is 19 ft. 2 in., the beam a T-section with 54x4-in. flange, and an 8x15-in. stem reinforced with 1.77 sq. in. of steel at 16 in. below the top of the slab. Figuring $E_s/E_c = 15$ and no tension in the concrete the neutral axis is 3.5 in. below the top of the slab. The dead load is 100 lb. per square foot. This would give us, when the maximum fibre stress in the concrete is 300 lb. per square inch, 16,000 pounds per square inch in steel and a total live and dead load of 212 lb. per square foot, or 112 lb. live load; and for $C = 500$ lb., 26,700 lb. in steel, and a live load of 254 lb. per square foot; and for the live load given in the article 350 lb. per square foot, or 450 lb. total load per square foot, a maximum fibre stress in concrete of 636 lb. per square inch, and in steel of 34,000 lb., which appears to be rather close to the elastic limit.

Yours truly,
J. M. Jirgensen.

New York, Feb. 5.

[This inquiry was submitted to the architects of the building, who have sent the following explanation of the figures.—Editor].

Sir: We have your letter of the 6th inst., also letter enclosed from J. M. Jirgensen, relative to the concrete floorbeams of the Ketterlinus building. Upon going over this, we note that the reinforcement as given in the article is for the roof beams and not for the floorbeams, as the reinforcement for the floorbeams consisted of one "Q" bar with 1 1/16-in. bulbs, the total area being 4 sq. in. and not four ¾-in. rods as stated. This is equivalent to about four 1⅛-in. bars.

We notice in the same paragraph it is mentioned that the "beams and floor slab are carried across the short spans at the columns by 11x18-in. concrete girders which are reinforced near the bottom with four ½-in. rods fixed in the same plane, and by four ¾-in. rods, two of which are bent up toward the top of the girder." The size of the reinforcement in these girders is also in error, as the girders were reinforced with two "Q" bars having ⅞-in. bulbs having a total area in the two of 6 sq. in. The manner of bending up the outside bulbs of the "Q" bar is substantially as mentioned in the article.

We furnished your representative with a framing plan of the building from which he took this information, and we presume that he inadvertently got the reinforcement for the roof framing instead of the floors. When the proof was submitted to us, we merely read it over in a general way and did not check each item of reinforcement; otherwise, we should have discovered that the reinforcement mentioned was for the roof instead of for the floor.

Yours truly,
Ballinger & Perrot.

Philadelphia, Feb. 7.

Steel Beams in Mill Construction.

Sir: Our attention has recently been called to what is claimed to be a new type of mill construction, and which is a very radical departure from the style of construction recommended by the mill mutual fire insurance companies of the East and by the National Board of Fire Underwriters. It is claimed that, owing to the advanced price of timber and the difficulty in obtaining yellow pine, or other suitable woods, within any reasonable period of time, that the mill engineers of the East have adopted the use of steel I-beams in place of wooden beams for this type of building. A spiking piece is bolted to the upper flange of the I-beam and the heavy splined floor and top or wearing floor placed on top of the spiking piece. The columns in this new type of construction are either wood or cast-iron.

The claim is made that this type of construction is taken by the mutual insurance companies at as low a rate as standard mill construction, and we are unable to reconcile the statement with the fact that the mutuals have always been adverse to any unprotected steel or iron work being used for structural members of buildings insured by them. We have been unable to find any printed matter in relation to this subject and, as we are always anxious to keep abreast of the times, we would be glad of any information you may be able to give us on the same.

Yours very truly,
McCreary, Wood & Bradney.

Buffalo, Jan. 31.

[This inquiry was sent to Mr. John R. Freeman, president of six important mutual insurance companies, who has kindly furnished the following note on the subject.—Editor.]

Sir: In reply to yours of Feb. 2, would state that we have been accepting for several years past the use of steel beams in the place of wooden beams, without making any difference in rate of premium. From the fire underwriter's point of view, we believe the steel beam decidedly inferior to the solid wooden beam, but from the manufacturer's point of view, there is sometimes a slight advantage in rigidity, and under conditions of to-day, it is becoming almost impossible to get quick deliveries on large timbers at a reasonable price.

We have come to have such high regard for the efficiency of automatic sprinklers, that we are content with the steel beam, largely because we expect the automatic sprinklers to keep it cool and to prevent the small fire from becoming a big fire. In this connection, you may be interested in a report of an important lesson again taught in the bad fire at the Cocheco Mills, Dover, ten days ago. This was constructed with heavy wooden beams of the double type, each beam composed of two timbers about 6 x 6 in., bolted together with an air space of about an inch in between.

The fire spread rapidly over the cotton on the machinery work up into these crevices between the two halves of the beam and was almost impossible to reach by hose streams. On personally inspecting the ruins a few days ago, I found many instances where the fire had, within this protected space, eaten its way into the two beams until they had become ruined and lost nearly all of their strength. The manager of the mill, Mr. Charles H. Fish, M. Am. Soc. M. E., who directed the fire fighting, tells me that the extinguishing of the fire in these crevices was one of their most difficult problems.

This double type of beam has been favored in the past by certain mill engineers because of its supposed greater freedom from dry rot, due to the access of the air to the inner surfaces of the beams. Moreover, it is sometimes easier to get the timber for the composite beams, and it has been argued by some that this method of construction tended to greater strength by showing up any defects in the timber, or by averaging against a weak stick the superior strength of an excellent stick of timber. My recent advice where double beams have had to be used, has been to bolt them as tightly together as possible. The shrinkage and barometric changes will give all necessary opportunity for access for air to the inner surfaces. It is plainly better to avoid any space between the beams.

Yours very truly,
Providence, Feb. 5. John R. Freeman.

Small Water Mains, 4 and 6 in. in diameter, are found to some extent in the distribution systems of the Boroughs of Manhattan and The Bronx, New York City, but they are being replaced by 8-in. mains or larger. Eight inches has been adopted as the minimum size for mains supplying residential districts.